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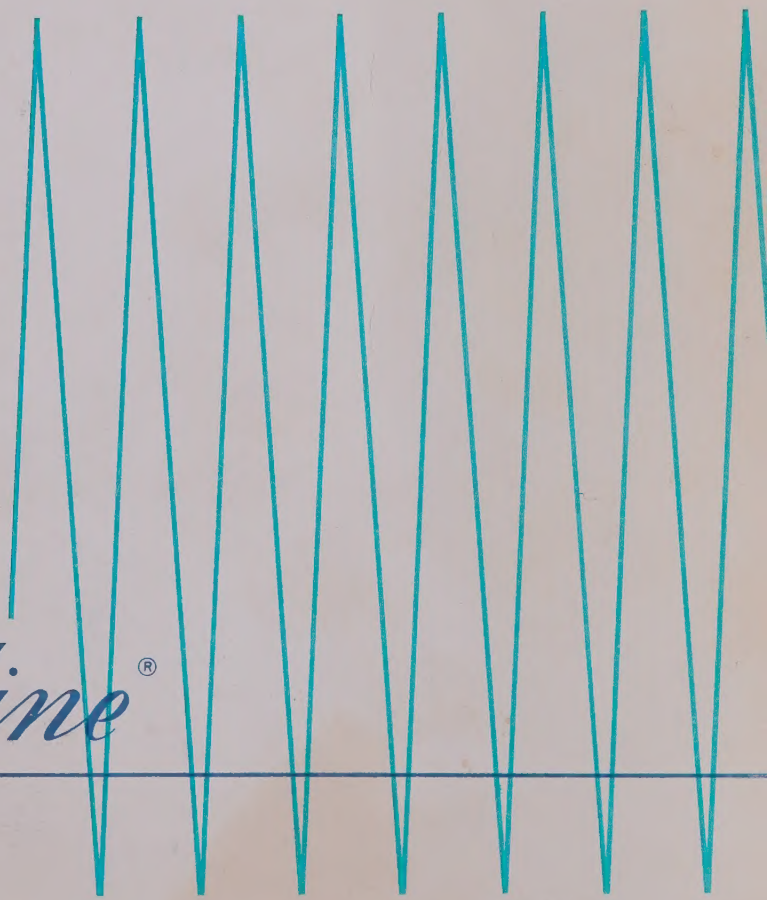
INSTRUMENT SHOP

MODEL 66A2
POWER METER-LEVELER
AMPLIFIER



SPERRY Microline®

MODEL 66A2
POWER METER-LEVELER
AMPLIFIER

SPERRY MICROWAVE ELECTRONICS COMPANY
DIVISION OF SPERRY RAND CORPORATION
CLEARWATER, FLORIDA

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SPECIFICATIONS

POWER METER APPLICATION	
POWER RANGES	7 Ranges: 10, 30, 100 and 300 μwatt, 1, 3 and 10 MW. Meter also calibrated in dbm from −30 to +10.
MOUNTS	Model 33B4, 33X4 (not supplied)
ACCURACY	All ranges, +20° to +35°C, ±3% of full scale. All ranges, 0° to 55°C, ±5% of full scale.
ZERO CARRY-OVER	When zeroed on most sensitive range, less than ±1% of full scale.
POWER SUPPLY	115 or 230 vac ±10%, 50 to 440 cps, 2.5 watts
RECORDER OUTPUT	1 ma, 2000 ohms max. impedance.
DIMENSIONS	Height 6½ in. Width 7¾ in. Depth 12 in.
WEIGHT	Net 7 lb. With Battery Pack 10 lbs. Approx.
LEVELER AMPLIFIER *	
LEVELING	±0.1 db at the sampling point.
RANGE	Continuously adjustable from 50 μwatts to 10 milliwatts at the sampling point.
SENSITIVITY	A 0.1 db change of power at the sampling point will cause a 0 to 50 volt control swing.

* Leveling operation permissible only on a-c line operation.

INTRODUCTION

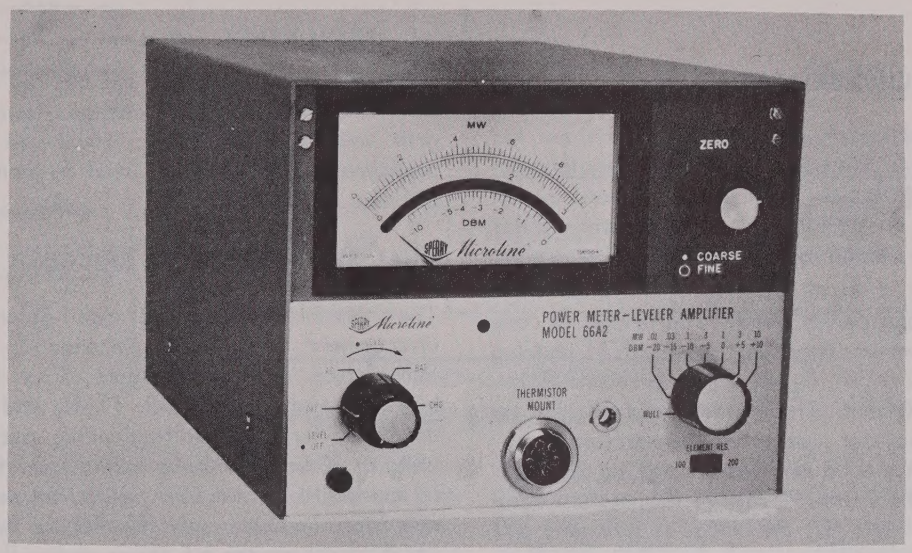


Figure 1. Microline 66A2 Power Meter-Leveler Amplifier

The Microline model 66A2 Power Meter-Leveler Amplifier is a completely transistorized, temperature compensated instrument capable of r-f power measurements from 1 microwatt to 10 milliwatts. Both coaxial and waveguide accessory mounts are available to cover a wide frequency range. An optional battery pack can be used for portable operation where a-c line power is not available.

The 66A2 is also designed for use as an accessory to the Microline 64( )1 series Microwave Swept Oscillator, providing power leveling over the operating band. This application permits external sampling directly in the setup and power is leveled to ±0.1 db at the sampling point. Frequency sensitive variations in power transmission from the 64( )1 to the setup are therefore eliminated. Absolute power level is under temperature compensated control with this arrangement and is continuously variable.

Provision is included for power measurement using d-c substitution from a precision external source. The normal metering circuits of the 66A2 are used simply for null indication with this setup and overall measurement accuracy is enhanced.

A dual thermistor and balanced bridge technique is used to reduce drift error to a low value over wide ambient temperature ranges. The thermistor mount uses a pair of thermistors enclosed in a thermal environment common to both and matched for thermal characteristics. Ambient temperature variations are "applied" equally to both elements and their effects cancel in the power meter. R-f power is applied to only one element and is indicated by the power meter.

Zero setting of the power meter is required only on the lowest range being used. With this setting, zero set accuracy is maintained within 1% as power meter range selection is advanced above the one where the zero adjustment is made.

Front panel meter indication is supplemented by a RECORDER jack connected in series with the meter and located on the rear of the 66A2. It supplies direct current, 0-1 ma, which is proportional to r-f power and may be used for the recorders, remote indication, digital voltmeters, controls, alarms or other applications.

The 66A2 is completely transistorized, minimizing power consumption. It may be operated from 115/230 volt power lines from 50-440 cps or from an optional internal, rechargeable battery. When the battery is installed, it is automatically trickle charged during a-c operation. The battery may also be charged at a higher rate after battery operation. The 66A2 may also be operated from any external 24 volt source capable of supplying 55 ma.

THEORY OF OPERATION

SELF-BALANCING BRIDGES

Currently, the most widely used technique for microwave power measurement is the self-balancing bridge. The Microlne 66A2 Power Meter-Leveler Amplifier is a dual bridge unit, but operation of the single bridge is basic to the dual bridge discussion.

Figure 2 is a block diagram of a typical self-balancing bridge power meter. The bridge is composed of the center-tapped secondary of T1 (making 2 arms of the bridge), R_O as a reference and R1 as the thermal element. The thermal element may be either a thermistor (negative temperature coefficient, or resistance decreases with an increase in power) or a barretter (positive temperature coefficient). When R_O = R1, the bridge is balanced and there is no output at the center tap. If R_O is larger than R1, output will be of one phase and if R_O is smaller than R1, output is of the opposite phase. Transformer and amplifier phasing is selected so the cold resistance of R1 is such that the loop oscillates. Power applied to R1 by this oscillation changes its resistance in a direction to reduce applied power. Since it cannot shut itself off, it stabilizes at a level determined by the power-resistance characteristic of R1. Application of power to R1 from an external source (such as r-f power or heat from increased ambient temperature) will tend to change the resistance and the oscillating loop will "back off" its applied power to maintain the stable bridge balance conditions.

Once the self-balancing loop has been established, the a-c level at the amplifier output may be measured and changes in a-c level used to indicate power applied to the thermal element from external sources. This arrangement provides a simple, straightforward power meter. Unfortunately, it is not possible to tell whether power from the external source is due to the desired r-f signal or from ambient temperature changes which appear as drift on the power meter. There are several approaches which may be used to compensate for ambient variations.

DUAL SELF-BALANCING BRIDGES

The 66A2 uses a dual self-balancing bridge arrangement to achieve compensation for ambient temperature variations. Figure 3 is a simplified block diagram of the 66A2. T1, R_O and R1, and the amplifier form the self-balancing oscillator operating at 10 kc. The 10-kc output from the oscillator is applied to T1 and T2 in series, but self-balancing operation involves only T1. R1 is the thermistor which receives the r-f power and will be referred to as the r-f bridge.

The second bridge has 10-kc power applied at whatever level is required to balance the first bridge. In operation, R3 is adjusted to match R2 and reduce bridge output to zero. Since T1 and T2 are identical, the balance between R2 and R3 will be almost identical to that between R_O and R1. The only difference will be due to mismatch between the thermistors.

When r-f power is applied to R1, the 10-kc oscillator output will decrease to maintain total power (r-f + 10 kc) in R1 the same as initially with 10 kc alone and maintain the initial degree of bridge balance. Since T1 and T2 are in series, 10-kc power in R2 is reduced at the same time, tending to unbalance the second bridge. The second amplifier and synchronous detector operate from the unbalance signal to generate d-c feedback which is applied to the second bridge to rebalance it. The first bridge is self-balancing on 10-kc and the second bridge is self-balancing with d-c.

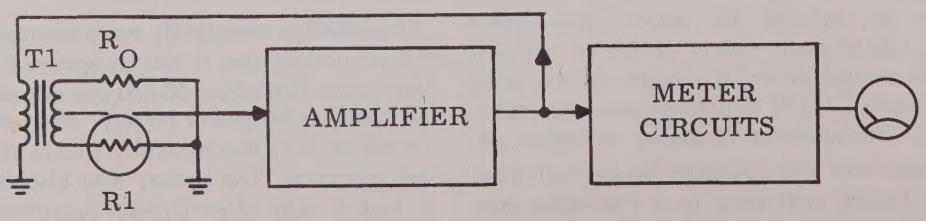


Figure 2. Typical Self-Balancing Bridge Power Meter

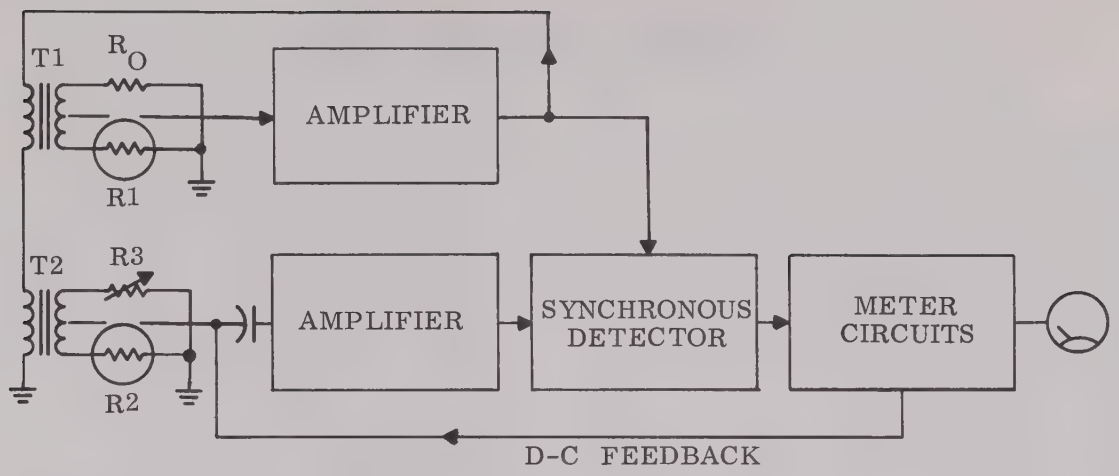


Figure 3. Dual Bridge Power Meter

Both R1 and R2 are mounted together to obtain the same response to ambient conditions in both bridges. An apparent change in power in R1 due to an ambient change will then cause a change in balance conditions, changing the 10 kc oscillator level. The second bridge will be changed by the same amount since the ambient change causes the same apparent power to appear in R2. Therefore, when R1 balances at its new power level, R2 also balances at the new power level and there is no net change in balance conditions.

Metering is done on the second bridge which is called the metering bridge. Since ambient changes are cancelled out in the metering bridge, it reads only r-f power applied to the r-f thermistor, R1. The output of the d-c feedback circuit represents the actual substituted r-f power and is proportional to the square of the feedback current. A squaring circuit in the metering circuit provides a linear meter scale to read r-f power directly.

LEVELER AMPLIFIER

Once a current (or voltage) proportional to r-f power has been obtained, it may be used to level the power output of a BWO oscillator. The power meter output current is compared to a fixed d-c reference and a difference amplifier is used to generate the correction signal for application to the BWO. If the d-c reference is made adjustable, the controlled power level may be continuously varied. Operation is very similar to a conventional feedback regulator.

ERRORS IN POWER MEASUREMENT

There are four important sources of error in microwave power measurements, mismatch error, mount losses, substitution error and instrumentation error.

Mismatch error accounts for that part of the power incident on the mount which is reflected because of the mismatch between the mount and the line. The net effect of this is difficult to evaluate because mismatch conditions along the line affect the magnitude of the variation. That is, if all power reflected from the mount is absorbed, the net power at the mount is different from that when power is reflected again by other mismatches back in the line. The limits of error may be determined from standard mismatch curves.

Mount losses account for that part of the power absorbed in the complete mount which is lost in the waveguide walls, matching structure, and other parts of the mount assembly.

Substitution error is caused by the difference between the effect of r-f power absorbed in the thermistor and 10-kc or d-c power absorbed in the element. That is, the heating characteristic of the element is dependent to some extent on whether or not heating is due to r-f impinging on the thermistor or a bias applied externally. There is also a certain amount of sensitivity to the frequency of the bias current. Both mount losses and substitution error are accounted for by the calibration factor or the mount. This gives the relation between r-f power absorbed by the complete mount and the power measured by substitution. Microline mounts typically run between 97% and 99%.

Instrumentation error is due to uncertainties in substituting power in the element and in reading out the amount of power substituted. The 66A2 is accurate to 3% or better in typical ambient temperatures when using its panel meter. Accuracy may be improved to 1% or better using the panel meter as a reference indicator for d-c substitution from an external source.

CIRCUIT DESCRIPTION

GENERAL

The model Microline 66A2 Power Meter-Leveler Amplifier is a dual bridge power meter which operates with the temperature compensated series of Microline thermistor mounts. Each of the dual bridges in the power meter includes a thermistor as a bridge arm. With respect to externally applied "power", the r-f bridge operates with its thermistor exposed to the r-f power and to ambient temperature conditions while the metering bridge thermistor is subject to ambient temperature conditions only. A combination block and schematic diagram is shown in Figure 4.

Both bridges are excited by a common 10-kc source. Feedback loop 1 is the 10-kc oscillator and is self-balancing with the r-f bridge. Excitation current ($I_{10\text{-}kc}$) to this and the metering bridge is supplied through the two transformer primaries in series (T1 and T2). The metering bridge is adjusted for balance (R7 and R8) at the 10-kc power level determined by the self-balancing conditions in the r-f bridge. Its feedback loop does not provide power at initial balance conditions.

When r-f power is applied to thermistor R_D, the self-balancing action removes an amount of 10-kc power from the r-f bridge equal to the applied r-f power. Since T1 and T2 are in series, the same 10-kc power reduction occurs in the metering bridge. Feedback loop 2 rebalances the metering bridge with d-c power equal to the reduction in 10-kc power. Since the 10-kc power change equals the r-f power, the inserted d-c power also equals the r-f power. The metering circuit senses the d-c feedback current, corrects it with the squaring circuit for linear meter indication and presents it on the panel meter.

The two thermistors are matched with respect to their temperature characteristics so only a small amount of zero drift occurs with ambient temperature changes. An ambient change is equivalent to a power change in the two thermistors and a new 10-kc power level is required in both to maintain bridge balance. The 10-kc level change is automatically provided by feedback loop 1 and occurs in both thermistors. D-c power is not changed since balance is maintained, and therefore no change in meter indication is produced by the ambient temperature variation.

A voltage proportional to r-f power is produced by passing the meter current through a resistor (R19). This is applied to a comparison circuit, generating an error signal which is amplified and applied to the BWO for power control. The reference voltage for the comparator is adjustable to permit continuous variation of the level at which BWO output is maintained.

R-F BRIDGE CIRCUIT

A simplified schematic of the r-f bridge circuit is shown in Figure 5. The bridge circuit consists of the r-f thermistor (R_D), reference resistors (R2 and R3) and the secondary winding of the bridge transformer (T1). Capacitor C_B represents the mount and cable capacities and C_A is used to balance the reference arm of the bridge against C_B. Operation of the self-balancing circuit, made up of the bridge and the feedback amplifier, is described in the Theory of Operation section.

METERING BRIDGE CIRCUIT

Figure 6 shows a simplified schematic of the metering bridge circuit. R_C is the compensation thermistor and is one arm of the bridge. The split secondary of T2 with R_B and C_D in parallel complete the bridge. R_B and R_C are equal and C_D balances cable and stray capacity in the other arm of the metering bridge. Self-balancing operation is similar to the r-f bridge circuit, but in this bridge, initial balance is set up with the 10-kc level from the r-f bridge oscillator. There is no d-c in the feedback loop at initial balance, obtained by adjusting R_B to balance with R_C. When the 10-kc level is reduced by self-balancing action in the r-f bridge, the resulting 10-kc error signal is amplified and a corresponding d-c signal produced by the synchronous detector. A d-c amplifier and bias circuit amplifier are then used to convert this d-c signal into the proper current, I_{DC}, and feed it back to the metering bridge, restoring bridge balance.

The d-c power inserted by the feedback loop to rebalance the bridge must equal the 10-kc power removed. Since the reduction in 10-kc power is equal to the r-f power applied to the r-f thermistor, the inserted d-c power is also equal to the r-f

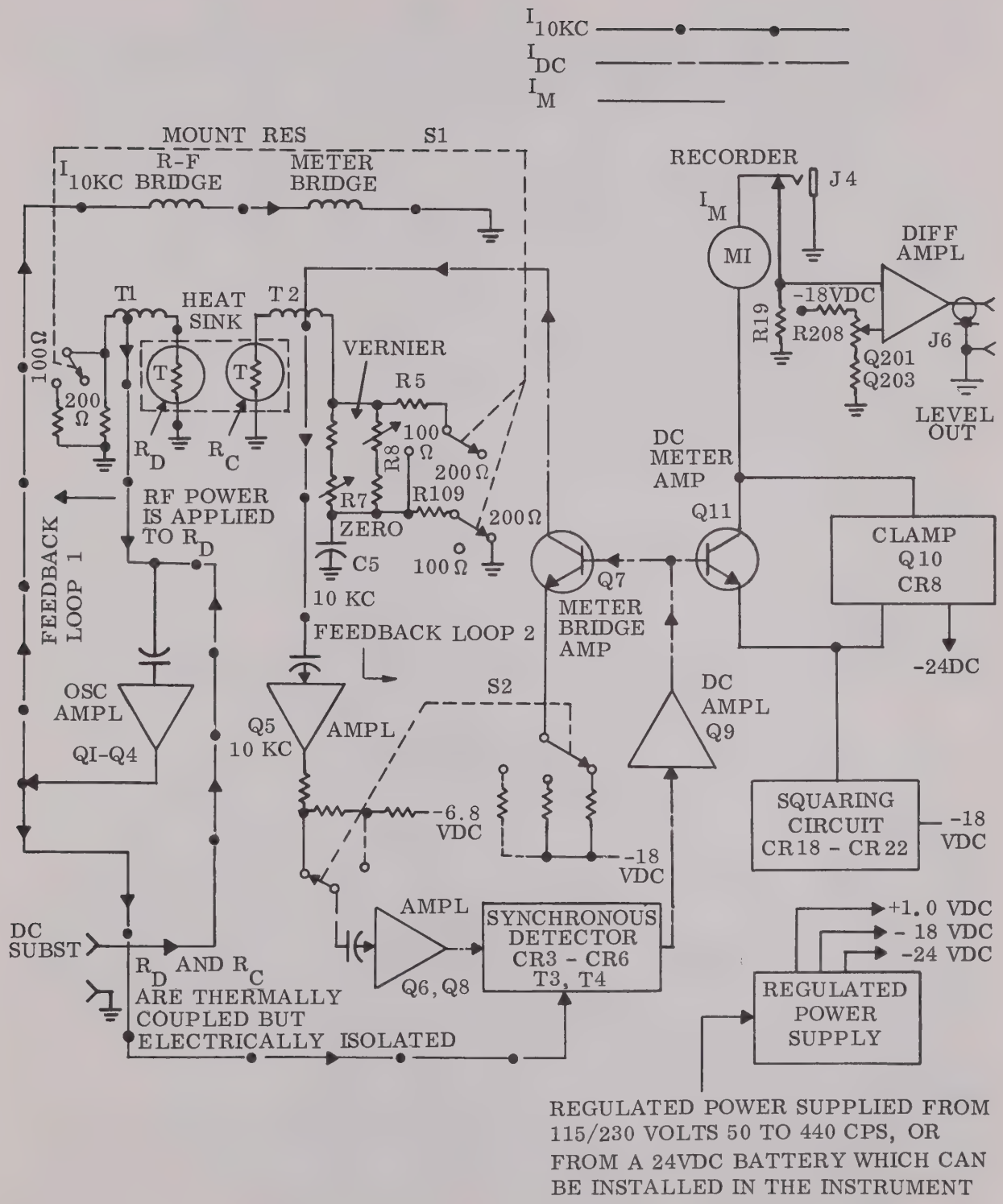


Figure 4. Microline 66A2 Power Meter-Leveler Amplifier, Functional Diagram

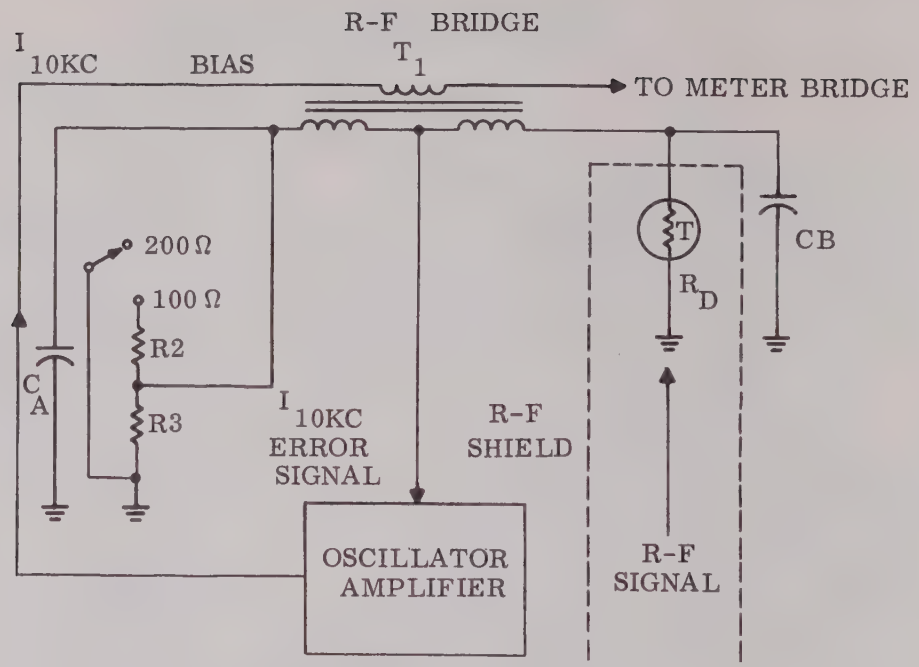


Figure 5. Simplified Schematic, R-F Bridge Circuit

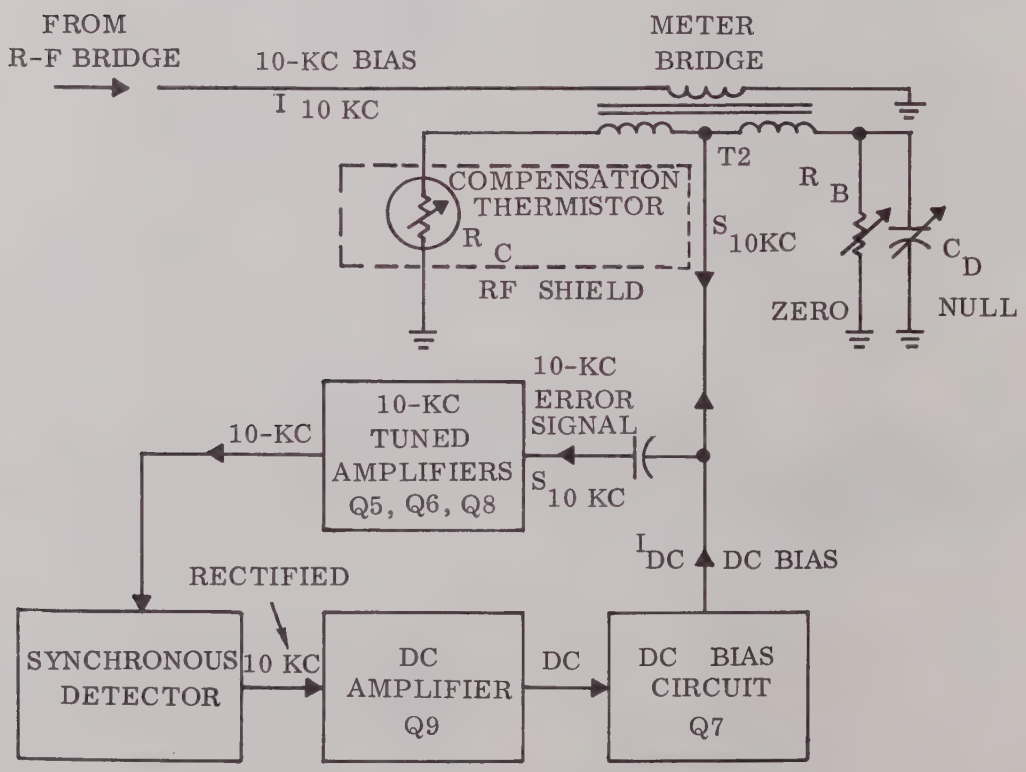


Figure 6. Simplified Schematic, Metering Bridge Circuit

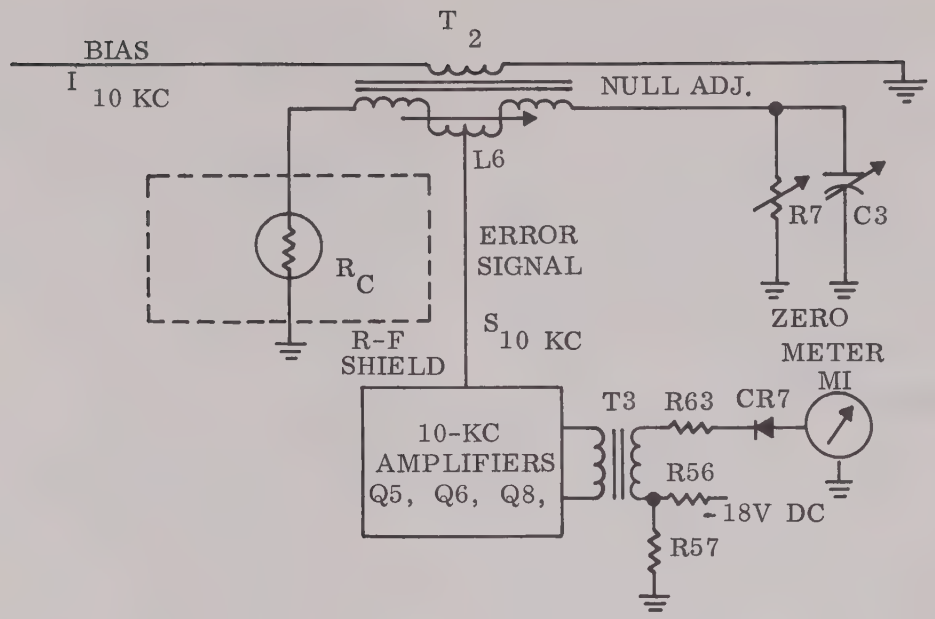


Figure 7. Power Meter Nulling Circuit

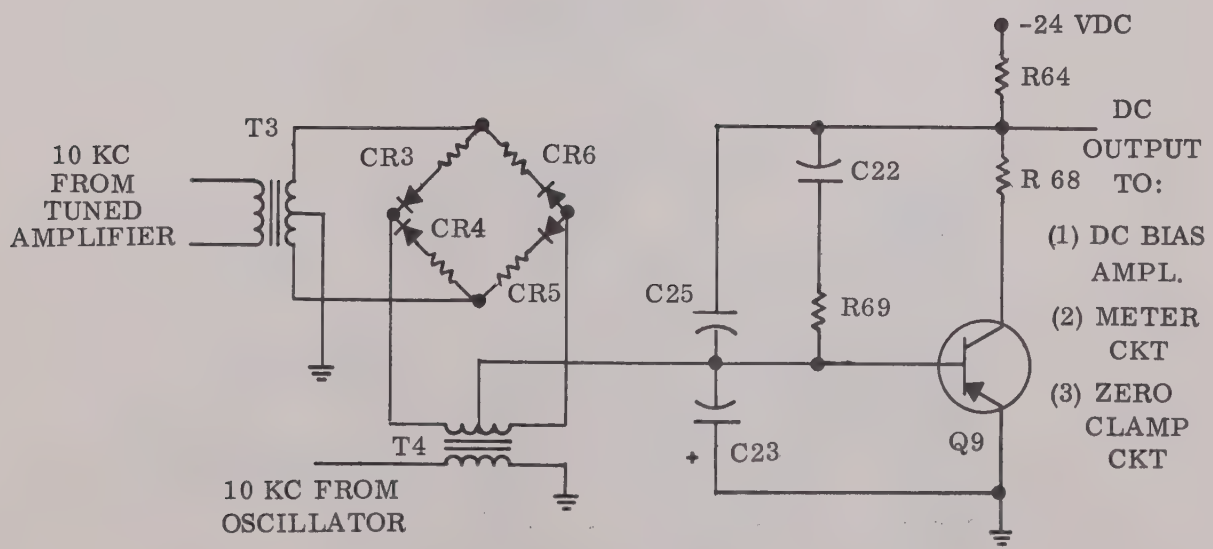


Figure 8. Synchronous Detector and D-C Amplifier, Simplified Schematic

power. It is now only necessary to meter the feedback d-c voltage properly to obtain a direct indication of r-f power.

NULL ADJUSTMENT

The circuit arrangement for null adjustment is shown in the simplified schematic of Figure 7. The bridge circuit is adjusted for near balance using R7. C3 is then adjusted for minimum output from the bridge (indicating reactive balance). L6 (and L5 in the r-f bridge circuit) are phasing adjustments made during instrument calibration.

SYNCHRONOUS DETECTOR AND D-C AMPLIFIER

Figure 8 shows a simplified schematic of the synchronous detector and d-c amplifier. A conventional full wave bridge detector is used with resistors in series with the switching diodes to improve balance. Output from the center tap of T4 is applied to the base of d-c amplifier Q9 and its filtering networks. C23 is the shunt filter and the network of C22, C25 and R69 is a feedback filter which is required for 10-kc suppression and loop stabilization in leveler operation.

METER CIRCUIT

The meter circuit includes d-c amplifier Q11, the squaring circuit and the panel meter. Figure 9 shows a simplified schematic. The function of the circuit is to convert the d-c voltage having linear control of feedback current to a linear meter indication of power (which is proportional to the square of the feedback current). Output voltage from d-c amplifier Q9 is applied to the base of the meter amplifier, Q11. Near zero input voltage, the effective emitter resistance is only due to R90 since the remaining circuits are disconnected by their diodes (which are reverse biased). As emitter current is increased, by increasing input voltage, the voltage between the emitter and the −18 volt supply overcomes diode biasing in succession, adding resistance in parallel with R90. This decreases the net emitter return resistance and increases the amount of current which flows in Q11 for a given input voltage. Diode bias points are selected to provide a square law relation between input and output (current is proportional to the square of the input voltage) and give a linear meter indication of power. The recorder output jack is in the d-c ground return for the meter. Resistor R19 develops input signal voltage for the leveler amplifier.

D-C BIAS AMPLIFIER

D-c bias feedback in the metering bridge is controlled by Q7, the d-c bias amplifier. A simplified

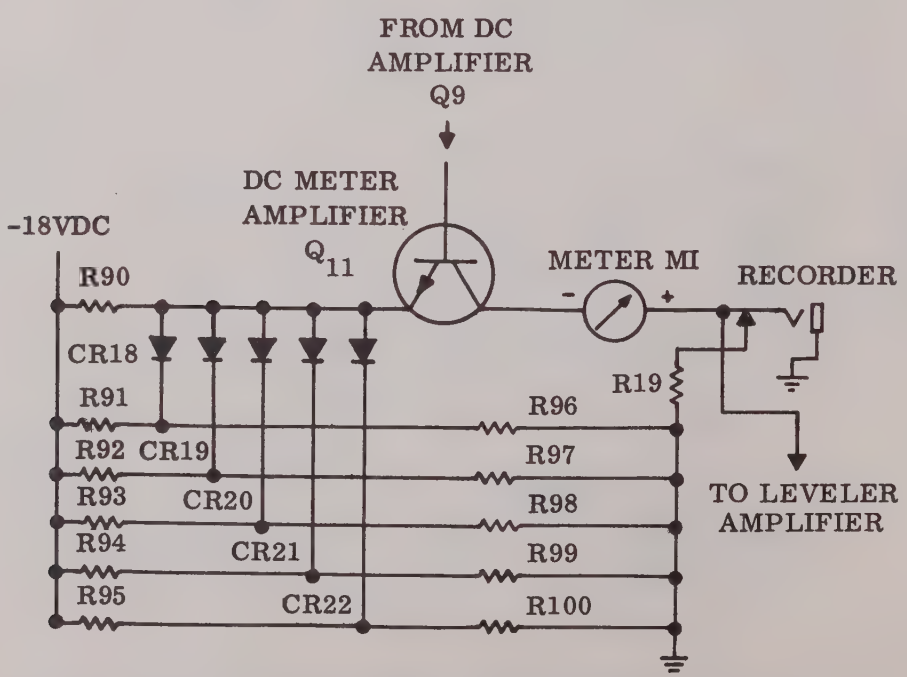


Figure 9. Meter and Squaring Circuit

schematic is shown in Figure 10. The base of Q7 is connected in parallel with the base of Q11, the meter amplifier. Base voltage range at Q11 is the same for all ranges of the power meter. Since this must correspond to different amounts of d-c power in the feedback circuit, depending on the range, the emitter resistor for Q7 is switched to provide the proper relation between base voltage and Q7 collector (d-c feedback) current for the range in use. This in turn selects the proper relation between meter indication and d-c feedback power because the input voltage for both the meter amplifier and d-c bias amplifier is the same.

ZERO CLAMP CIRCUIT

The third circuit operating from the d-c amplifier output is the zero clamp circuit of Q10, CR8 and the associated resistors shown in Figure 11. When the meter indicates upscale (voltage applied to base of Q10), Q10 conducts and applies reverse

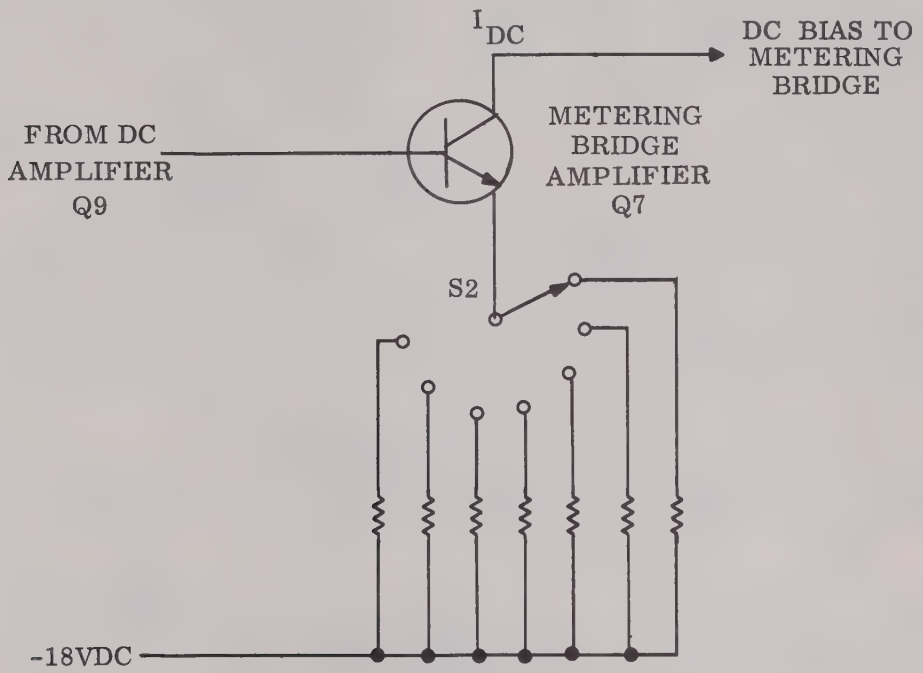


Figure 10. Metering Bridge Amplifier

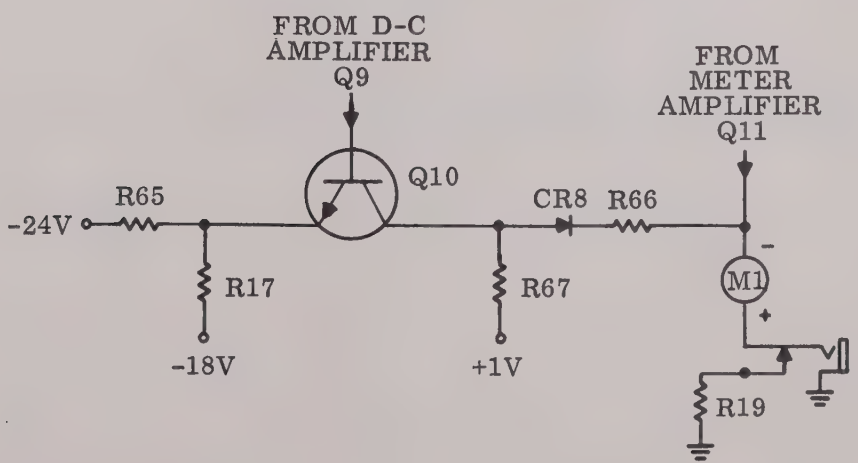


Figure 11. Zero Clamp Circuit

bias to CR8 from the voltage drop across R67. When the base voltage is reduced to zero, Q10 is cut off, CR8 conducts and a reverse meter current is available to permit accurate zero adjustment of meter M1.

POWER SUPPLY REGULATORS

Figure 12 shows a simplified diagram of the power supply regulators. The −18 volt supply is controlled by a conventional series regulator circuit (Q12-Q16) and the −24 volt supply is regulated to it by Zener diode CR16. R73, in the power supply return, provides approximately +1 volt. The positive voltage is not critical in its value and does not require regulation.

POWER SWITCHING CIRCUIT

The power switching circuit is illustrated in simplified schematic form in Figure 3-10. The operation mode selection switch on the power meter front panel has four positions: OFF, AC, BATT, and CHARGE. With the mode switch in the AC position, the power meter operates on either 115- or 230-volt a-c power. A trickle charge is also supplied to the battery, if this item is installed in the equipment.

When the mode switch is placed in the BATT position, the power meter is completely dependent on the 24-vdc source. With the internally installed battery, the power meter becomes a portable test instrument. When the mode switch is placed in the CHARGE position, the internal battery is charged through d-c supply A (see Figure 13). A current of approximately 30 ma dc is applied to the battery during the charging period. The power meter cannot be operated during this period.

LEVELER AMPLIFIER

A simplified schematic of the leveler amplifier is shown in Figure 14. Current from the metering amplifier flows through R19 and develops a voltage proportional to the meter current (and r-f power). This voltage is applied to the base of Q202 which is one of the differential pair Q201-Q202. The base of Q201 is connected to R208 which supplies the reference voltage from a resistive divider across the regulated −18 volt supply. Q203 is driven by

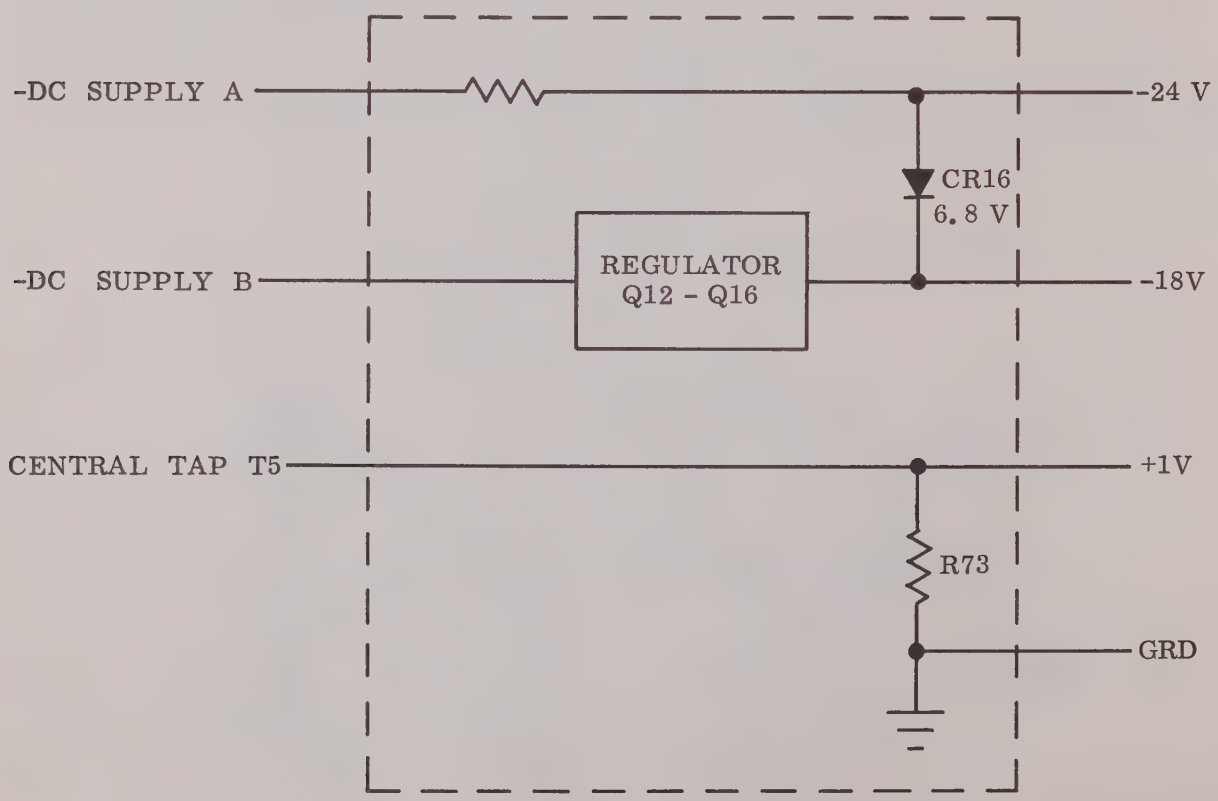


Figure 12. Power Supply Regulators

the error voltage developed in the collector circuits of Q201 and Q202. Output voltage is developed across R207 and varies from about −10 volts to about +68 volts, depending on the results of comparing the input to the reference in the differential amplifier. In the maximum CCW position of the LEVEL control (R208), switch S201 opens and applies maximum cutoff bias to the BWO tube. This permits convenient switching of the r-f source for adjusting the setup, zeroing the power meter and other operations. Phasing of the input-output voltage in the leveler amplifier is such that it adjusts the r-f power to regulate the voltage developed at R19, matching it to the reference and maintaining constant power.

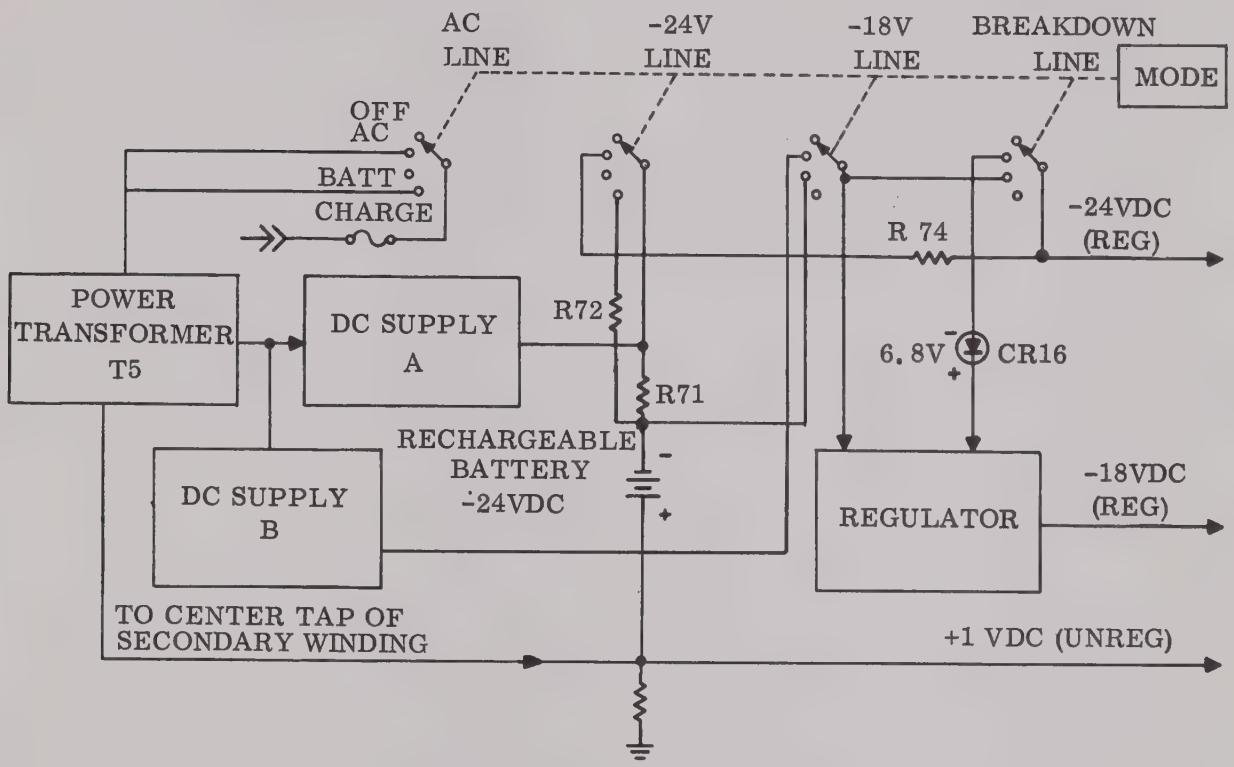


Figure 13. Power Switching Circuit

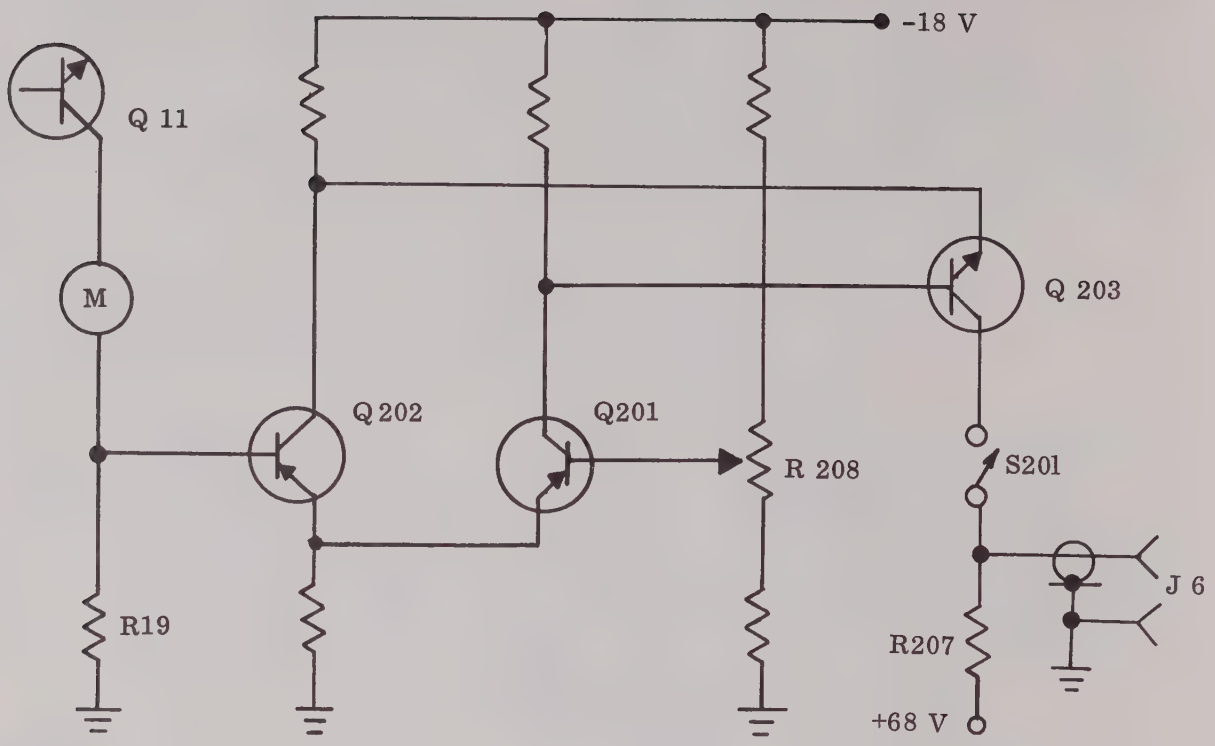


Figure 14. Leveler Amplifier

OPERATION

INSTALLATION

Unpacking and Inspecting

On receipt of the power meter, perform a preliminary visual inspection of the carton for evidence of damage during transportation. Any evidence of serious damage should be reported to the carrier prior to unpacking the equipment.

If there is no evidence of damage, unpack the equipment, following conventional unpacking procedures and using care. Retain the shipping carton for reuse, if later reshipment is anticipated.

The power meter was tested and inspected at the factory before shipment. Immediately after unpacking the equipment visually inspect it for damage which may have occurred in transit, such as broken knobs, scratches on panels, damaged meter, etc. Following the visual inspection, check the power meter electrically using the procedure given in the Performance Test Paragraph. If there is any evidence of damage immediately file a claim for damage in transit with the carrier. Refer to the Reshipment Paragraph for general instructions on packing for reshipment.

A-C OPERATION

For a-c operation, the power meter is supplied with an accessory detachable three-conductor power cable. This cable terminates in a polarized three-prong male connector at one end and in a female connector at the other end. The offset round pin of the male connector is connected to the chassis of the equipment for the ground connection. Make certain that the slide-switch on the rear panel is in the proper position before connecting the power meter to an a-c source.

It is the recommendation of the NEMA (National Electrical Manufacturer's Association) that all exposed parts of this type of equipment be grounded for the protection of using personnel. When connecting the three prong connector to a two-contact outlet, a three-prong to two-prong adapter should be used with the green lead on the adapter being connected to ground.

230-Volt Operation. To convert the power meter from 115-volt operation to operation from a standard 230-volt a-c source, move the slide switch on the rear panel to 230-volts. It is not necessary to change the fuse when switching to 230-volt operation.

CONNECTING THE THERMISTOR MOUNT

The thermistor mount connects to the power unit through a multi-element coaxial cable which plugs into the THERMISTOR MOUNT six-contact socket on the power meter front panel.

NOTE

Thermistors are temperature sensisitive devices. A cold thermistor mount connected to a warm equipment, or a warm thermistor mount connected to a cold equipment, produces rapid drift. Therefore, to minimize drift on sensitive ranges make certain that the mount and the equipment are at approximately the same temperature before making a measurement.

PERFORMANCE TEST

A quick test to assure that the equipment will function properly may be made by nulling the meter. Refer to the Nulling The Power Meter instructions. Connection of an r-f source to the power meter is not necessary for this test.

Complete performance tests are detailed in the Maintenance and Adjustment section of this manual.

Battery Installation and Operation

The optional battery for the 66A2 is a rechargeable 24-volt nickel-cadmium battery. If purchased with the power meter, the battery is installed at the factory before shipment. If purchased separately the battery is supplied with a mounting kit and complete installation instructions.

For battery operation of the equipment, use the following procedure:

a. Connect the power meter to an a-c source using the power cord supplied with the equipment. Set the OFF-AC-BATT-CHARGE (mode) switch on the front panel to CHARGE and charge the battery for a minimum of 16 hours.

b. Be sure the power meter is operating normally by using the normal operating procedure given in the A-C Operation portion of the Power Meter Operation paragraph.

c. Set the mode switch to BATT (the pilot lamp will not be on), readjust the zero setting and apply r-f power using the appropriate procedure given in the D-C Operation portion of the Power Meter Operation paragraph.

Further instructions on the use and recharging of the battery are given in the Operation paragraphs of this manual.

To use the power meter with any external d-c source capable of delivering 55 ma at 24 volts, proceed as follows:

a. Turn the mode switch to the OFF position.

b. Remove the covers of the 66A2 following the instructions of section

c. Connect the external source to the proper terminals on the main printed board (marked B+ and B-) at the left rear of the board.

CAUTION

Any ground connections in the external supply must be compatible with ground connections (including the r-f setup) present in the power meter and any associated equipment.

d. Replace the 66A2 covers. The unit is now ready for operation.

RESHIPMENT

If possible, in the event the power meter was damaged during shipment, or if the equipment requires repair, use the original packing container and materials. If a substitute shipping container is used for reshipment, make certain that it has strong cardboard or wooden sides and heavy wrappings. The power meter should be surrounded by ample padding when placed in the container. After packing, the container should be clearly marked "FRAGILE" and "DELICATE INSTRUMENT" on the surfaces.

OPERATION

Connection to Power Source

The *Microline* 66A2 Power Meter-Leveler Amplifier may be operated from the battery or external d-c power source as well as from an a-c power line. In addition it will supply current for charging the battery. The mode of operation is selected by positioning the OFF-AC-BATT-CHARGE switch (mode selection switch) on the front panel of the power meter. With this switch in the AC position, the power meter can be operated from either a 115-volt or a 230-volt, 50-to 440-cycle, power line. When the equipment is operating on the a-c power line, 4 ma is supplied to the internal battery for trickle-charging. With this switch in the CHARGE position, approximately 30 ma d-c charging current is supplied to the battery.

With OFF-AC-BATT-CHARGE switch in the BATT position, the equipment can be powered from a d-c source. This source may be either the internally connected 24-volt nickel-cadmium battery, or a 55 ma 24-volt external battery or equivalent d-c power supply.

When using the internal battery for operation of the power meter, it is important that the battery be kept at full or near-full charge. Information on battery use and charging is given under Battery Use and Charging. The Microline battery supplies approximately 50 ma to the power supply, and all circuits are fully d-c regulated as in a-c operation.

Connections to the input power transformer are determined by the position of the two-position (115 or 230) line voltage slide-switch on the rear panel of the power meter. The line voltage switch must be positioned for the proper nominal line voltage of the a-c power source prior to attaching power cord set to the a-c source.

Pre-operational Adjustments. Before r-f power measurements can be made, both thermistor bridges must be in balance and biased only by the 10-kc current. The r-f bridge is self-balancing, and during operation the metering bridge is also self-balancing. Initially, both phase and balance adjustments are necessary to bring the metering bridge into balance.

Nulling the Power Meter

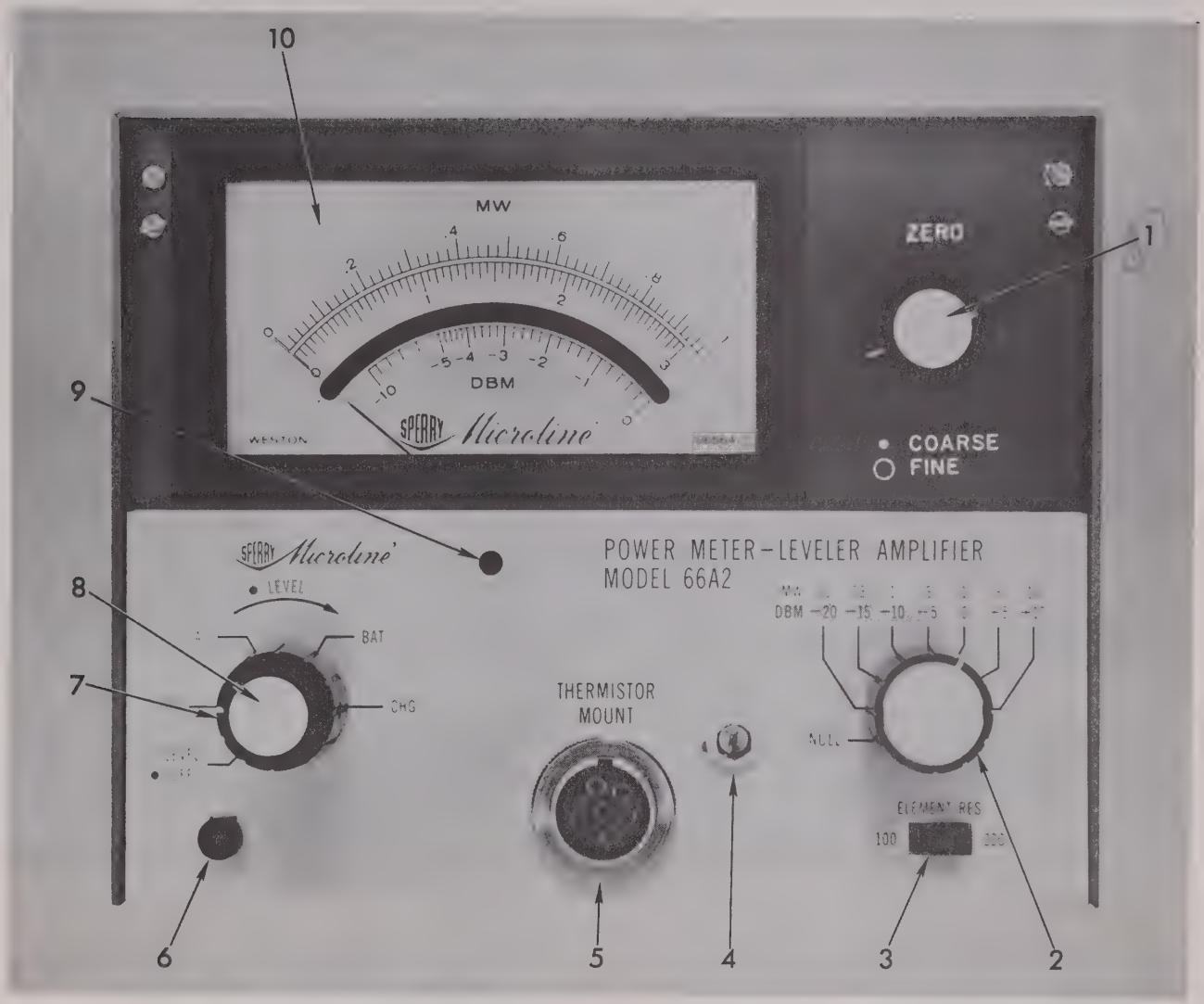
The NULL adjustment is operational phase balancing of the metering bridge. This is done using the front panel NULL control and the following procedure:

a. Connect the power meter to the desired mount and set the ELEMENT RES. switch to the correct position. Make the desired power connection (a-c or d-c) and turn the power meter on (AC if a-c is used; BATT if d-c).

b. If the power meter is in a leveler setup, turn the LEVEL control maximum CCW until the switch operates. This biases the BWO to zero power output.

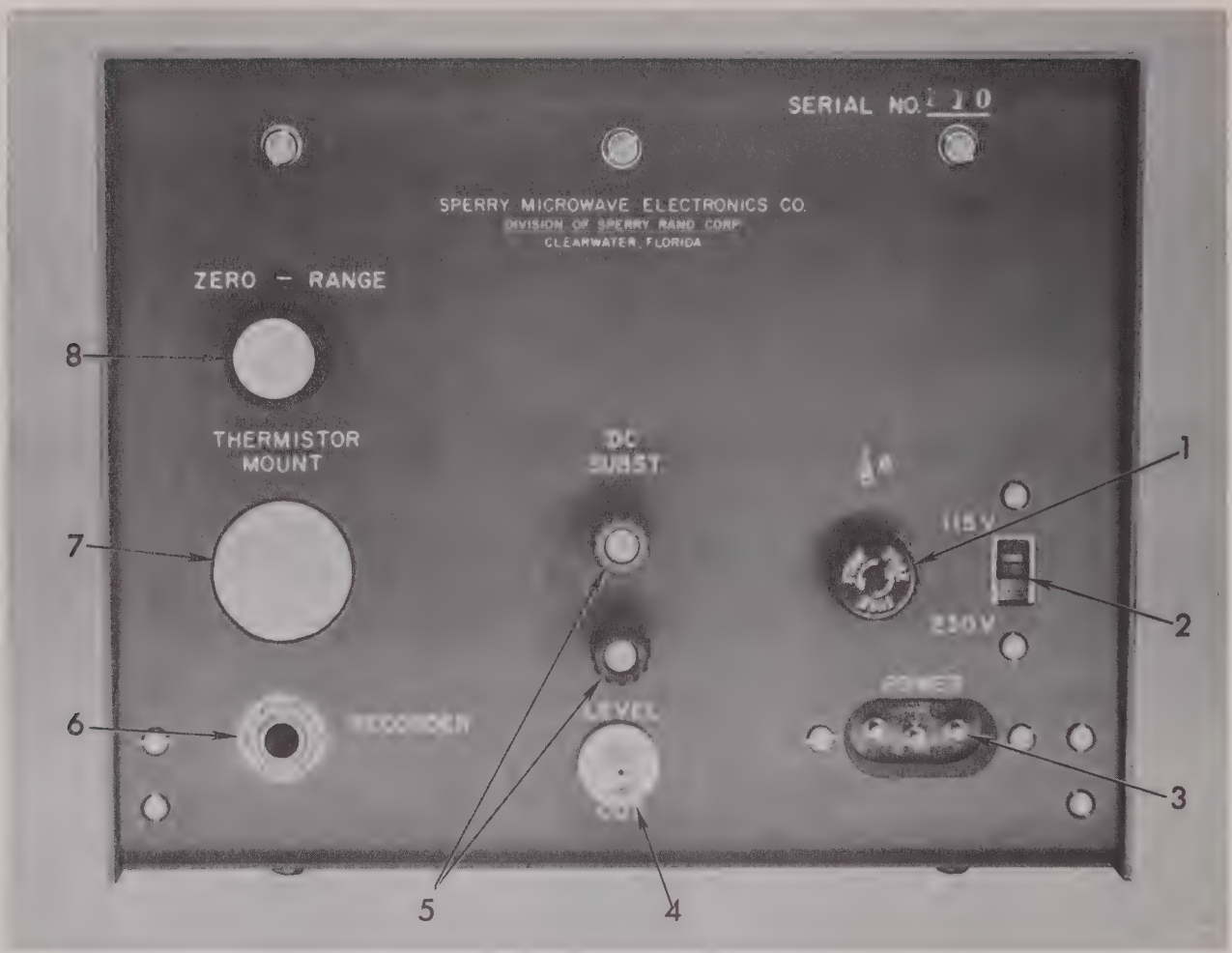
CAUTION

Never turn the 66A2 range switch to the NULL position when in a leveler setup without performing the step above. To do so will result in zero bias on the BWO and will produce maximum BWO output with possible damage to the thermistor or components in the r-f setup.



1. D-C zero-set knob (with vernier)
2. Range selection switch
3. ELEMENT RES switch for selecting network for 100-ohm or 200-ohm bolometer mount
4. NULL adjustment for a-c balance of bridge
5. Receptacle for bolometer mount cable
6. Pilot lamp (lights only during a-c operation or during battery charge, not during battery operation)
7. Power mode selector switch
8. Level control
9. Meter mechanical zero set
10. Power meter

Figure 15. Front Panel Controls and Indicators



1. Fuseholder for 1/8 ampere slo-blo fuse
2. Slide switch for selecting 115-volt or 230-volt operation
3. Power input connector
4. Level output
5. Terminals for application of substitution d-c currents, for calibration, or for very accurate measurements.
6. Output jack for recording equipment
7. Location for optional rear-panel bolometer-mount-cable receptacle
8. Zero range control

Figure 16. Rear Panel Controls and Connectors

c. Set the range switch to .01 MW and adjust the ZERO controls for a panel meter indication between zero and mid-scale.

d. Turn the range switch to NULL and adjust the NULL control with a screwdriver until the panel meter reads minimum.

e. If the minimum indication is not less than 0.15 on the 0-1 scale, repeat steps c. and d. above.

The NULL adjustment is in one arm of the metering bridge. Normally, readjustment is not required after the above procedure unless the mount or cable is changed. The setting of the coarse ZERO control may have a slight effect on the NULL, but once adjustment is made, it will normally hold for a given mount.

Zero Adjustment

The metering bridge is balanced by adjusting R7 and R8, the coarse and fine knobs on the ZERO control. After the 66A2 is connected to the desired mount and the ELEMENT RES. switch set in the proper position, the following procedure is used for zero adjustment:

a. Turn the mode switch to OFF. Check that the panel meter reads zero. If it does not, zero it mechanically using the procedure in the Maintenance and Adjustment Section.

b. Turn the power meter on. If a leveling setup is being used, turn the LEVEL control to the maximum CCW position until the switch operates.

c. The ZERO RANGE switch on the rear panel should be set to its mid position (it is a 5 position switch).

d. Set the range switch to the lowest range to be used in power measurements.

e. Adjust the ZERO controls until the panel meter indicates zero. On the lower ranges, there may be an initial period of zero drift until the thermistor mount stabilizes. It it is not possible to zero the meter, set the ZERO RANGE switch to a different position and repeat the zeroing procedure. If no position of the ZERO RANGE switch is found which will permit proper zero adjustment, the thermistor mount should be checked.

f. Apply r-f power and read the panel meter indication. Power meter ranges may be changed without readjustment of zero setting, but ZERO controls must be adjusted on the lowest range used.

g. If the ambient temperature is fluctuating, the zero adjustment may drift slightly, especially on low ranges. If this effect makes maintenance of zero adjustment difficult, the ZERO controls may be set for a convenient panel meter indication (say 0.1), the r-f power applied, the upscale reading noted immediately, and the r-f removed with the downscale reading noted immediately. The difference between the initial reference setting and the upscale reading may be averaged with the difference between the upscale reading and the final downscale reading to obtain the r-f power.

The zero adjustment should be checked from time to time, especially during the first 20 minutes or so of operation while temperatures in the setup are stabilizing. This is particularly true when operating on the lowest power meter ranges. Mechanical shock to the equipment may cause the zero adjustment to shift slightly and if any such shock occurs, the setting should be checked.

While the 66A2 will operate within specifications over the full range with zero adjustment only on the lowest range used, maximum instrument accuracy will be realized if zero adjustment is made on the range in use.

OPERATION OF THE POWER METER

The following instructions cover both the a-c operation and the d-c operation of the Microline 66A2 Power Meter-Leveler Amplifier. The power meter should be properly adjusted for null and zero-setting prior to making r-f power measurements. These instructions include measurement information and precautions to be observed when using a thermistor as the power-sensing element.

A-c Operation

To operate the 66A2 power meter from an a-c source, proceed as follows:

a. Make certain that the line voltage slide switch on the rear panel is in the correct position before making any connection to the power source.

b. Plug the power cable into the 66A2 and attach to the a-c source.

c. Set the ELEMENT RES. switch on the front panel to the proper position for the mount in use (see label on mount).

d. Connect the mount to the 66A2 with the cable supplied. Be certain that locking rings on both panel and mount are tightened securely.

CAUTION

Avoid mechanical shocks to the thermistor mount. Avoid scratches on the flange, dirt on the flange or in the waveguide mount.

e. Turn off the r-f power. If in a leveler setup, turn the LEVEL control on the 66A2 to the maximum CCW position until the switch operates.

f. Check mechanical meter zero. (power meter off).

g. Set the mode switch to AC. The indicator lamp will come on.

h. Check the NULL adjustment. (see Nulling The Power Meter).

i. Set the range switch to either the lowest range to be used or to the range desired and zero the meter with the ZERO controls. (see Zero Adjustment).

j. Apply r-f power and read directly on the front panel meter. The 66A2 indicates average power for c-w or modulated power when the modulation rate is above about 10 cps.

CAUTION

Never apply excessive power to the thermistor. To measure power at levels above 10 mw, insert a calibrated attenuator or coupler between the source and the thermistor mount.

D-c Operation

The procedure for d-c operation is the same as for a-c operation given in the preceding paragraph except that the mode switch is turned to BATT to turn on the 66A2.

CAUTION

Never operate with a discharged battery. The battery may be damaged by excessive discharge. Allow two hours charging for each hour of use.

LEVELER OPERATION

The Microline 66A2 Power Meter-Leveler Amplifier is designed to operate with the Microline 64( )1 Microwave Swept Oscillators to provide a source of leveled r-f power. Except for the sampling coupler and thermistor mount-power meter combination, no other accessory equipment is required to add 0.1 db leveling to the 64( )1.

Setup

A typical setup is shown in Figure 17. The coupler should have as flat a coupling characteristic as

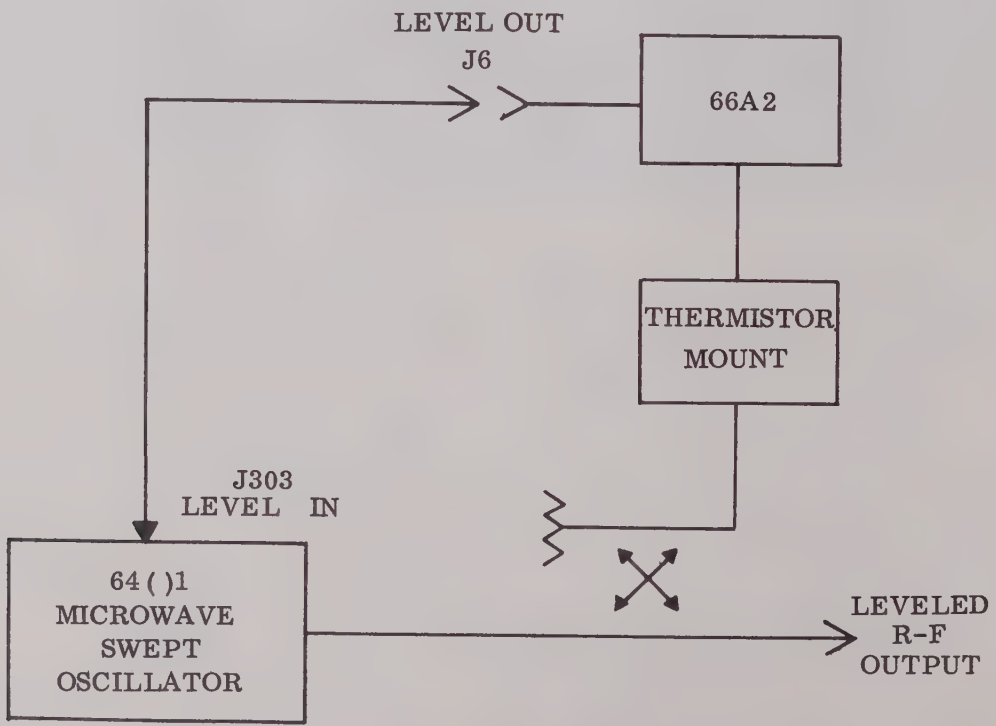


Figure 17. Leveler Setup

possible across the band since the power meter levels to the output measured at the side arm. Output from the main arm of the coupler will be level across the band to 0.1 db plus the variation in the side arm coupling. Directivity should be as high as possible to insure leveling from incident power only. An isolator is recommended as standard good practice not only to minimize reflected power in the coupler, but to protect the coupler and swept oscillator from the effects of high VSWR loads. A complete series of isolators is available from Sperry.

Leveler Setup Operation

With the setup of Figure 17, the following procedure is used to operate the leveler:

a. Turn the LEVEL control on the 66A2 to the maximum CCW position until the switch operates.

b. Turn on the 64( )1 Swept Oscillator and the 66A2 and allow equipment to warm up.

c. Select the power level desired and set the 66A2 range switch to the proper position. Power in the main arm will be higher than that at the thermistor mount by the amount of loss in the coupler. If a 10-db coupler is used, the sampled power at the thermistor mount will be 10 db less than that in the main arm. For example, if 10 mw of leveled power is required, the power meter would be set for 1 mw using a 10 db coupler. Zero the 66A2.

d. Advance the LEVEL control clockwise until the switch JUST operates. The 66A2 panel meter will stabilize at about 0.3 full scale.

e. Continue to advance the LEVEL control until the desired power level is reached. This power level will be maintained by the leveler as the BWO is swept or changed in frequency.

f. Power level may be switched in 5 db steps by turning the 66A2 range switch to successive ranges. The power level will be maintained automatically at the proper level.

Precautions in Leveler Operation

It is not possible to level BWO output power at a level higher than the minimum power output. That is, a 64X1 with a minimum output power of 20 mw cannot be leveled at 25 mw across the band because the tube will not be able to produce 25 mw at all points. Leveling is possible at values higher than minimum power over selectedportions of the band, generally near the high end. To determine whether or not the 66A2 is leveling, sweep slowly through the band of interest while watching the panel meter. A sudden dip in the reading of more than 0.1 db indicates that a point has been passed where power output is less than the level which is set by the LEVEL control. It may be reset for a slightly lower level until the dip is no longer observed.

Under certain favorable conditions of BWO characteristics, overall loop gain and r-f load, it may be possible to level below 50 μw at the thermistor mount. Generally, the 66A2 leveling setup approaches a marginal condition on the two lower ranges and low frequency oscillation may occur. Oscillation will be evidenced by a periodic fluctuation of the panel meter. This condition generally is present near the upper end of the BWO frequency range. Setting the 66A2 range switch to a higher range will usually stop the oscillation.

If the output of the coupler main arm is poorly matched, excessive r-f loop gain may result and with certain BWOs, oscillation may occur in the leveling loop at power levels above 50 μw. If this condition exists, an isolator should be used between the coupler main arm and the load. If an isolator is not available, the loop will usually operate satisfactorily if switched to a higher power range.

Leveling at the output of the coupler main arm is constant to within 0.1 db plus coupler variations. Care should be taken in selecting components to follow the coupler because their insertion loss variations with frequency introduce additional fluctuation in the power vs. frequency curve. Variable attenuators (except rotary vane) are usually very frequency sensitive. Any tuned device will naturally be frequency sensitive. The individual setup should be examined from this point of view before any assumption is made about the degree of leveling at the actual test point in the setup. Variations which appear between the swept source and the coupler are removed in the leveling operation.

D-C SUBSTITUTION METHOD OF PRECISION MEASUREMENT

Test instruments with a very high degree of accuracy are available for measuring direct current. Therefore, there is considerable advantage in the use of a method whereby the r-f power measurement is used only as a reference and the determination of the r-f power level is based on values obtained by precision d-c measurements. This technique is

useful where optimum accuracy is required, and, in general, involves applying r-f power to the thermistor in the normal manner and using the reading obtained as a reference; then applying sufficient dc to the thermistor to obtain exactly the reference reading. The value of the dc required to duplicate the reference reading is determined by either measuring the applied dc using a precision milliammeter, or by measuring the voltage drop when this dc is applied across a precision resistor of known value. The r-f power is then calculated.

The accuracy of the d-c substitution method of measurement depends principally on how precisely the (r-f) reference measurement is duplicated, and on how accurately the value of the substituted dc is known. More accurate measurements can be obtained if the exact value of the thermistor operating resistance, and the exact ratio of current division in the r-f bridge, are known. However, by using precision components in the substitution test setup and care in making the measurements, an accuracy of 1% or better can be obtained. The nominal resistance value shown on the thermistor mount name plate is used, and an assumption is made that one-half the applied dc flows through the r-f thermistor.

The following equipment is recommended for making precision measurements by the d-c substitution method:

A variable 300-volt, 20 ma, d-c power supply. A potentiometer with a fixed power supply may be used if a variable supply is not available. The series 10,000 ohm resistor below must be used in any case.

A resistor having a minimum value of 10,000 ohms (10-watt) is required to protect the power meter 10-kc oscillator from frequency pulling. Resistance tolerance is not critical and a 10% resistor may be used.

A precision milliammeter or precision voltmeter having an accuracy of at least 0.2% to measure inserted d-c. The voltmeter should preferably be of the digital type and will require a precision (0.05% tolerance) 1000-ohm resistor for the current measurement. The positioning of this meter is shown in Figure 18.

A precision voltmeter (preferably the same type as above) to indicate output current of the 66A2. This is optional and may be used to improve resolution in determining the reference level at the 66A2 output over that obtained with the panel

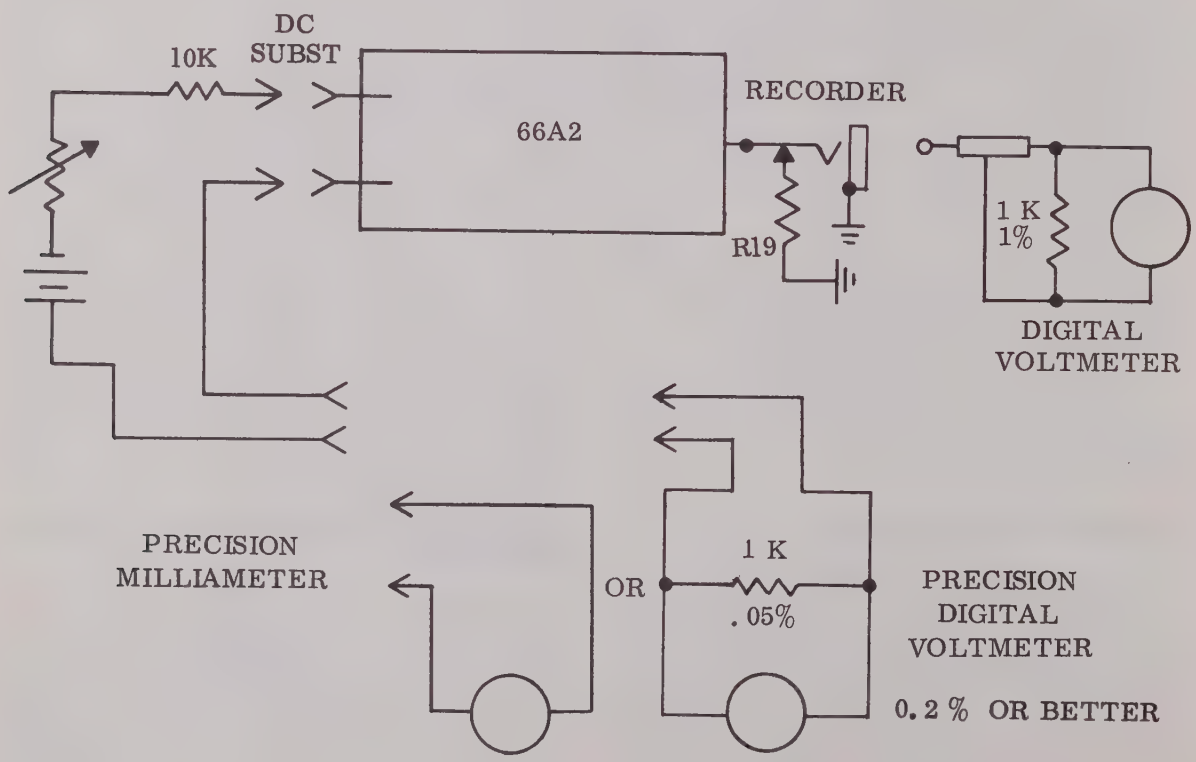


Figure 18. Test Setup for D-C Substitution Method of Measurement

meter. A 1000-ohm resistor (½ watt, 1%) should be used to measure the output current.

The test setup is shown in Figure 18. Proceed as follows to make the d-c substitution measurement:

Connect the system, using the test equipment itemized above, as shown in Figure 18. Place the 1000-ohm resistor in parallel with the inputs of the precision voltmeters. The d-c power supply is not connected to ground, and on both voltmeters the ground clip is disconnected. Ground currents are avoided by using only the power meter ground. Place the 10,000-ohm resistor in series with the d-c supply to the D.C. SUBST. Red binding post (5, Figure 16) and installed close to the post.

CAUTION

Do not apply more than 20 ma to the D.C. SUBST. (3) input.

Prepare the power meter for operation as outlined under A-C operation.

Apply r-f power to the thermistor mount, and note the indication on voltmeter No. 2 (see Figure 18), which is connected to the RECORDER jack (5, figure 16). If this voltmeter is not used, note the indication on the 66A2 panel meter. This indication is the reference reading.

Remove r-f power and apply dc while watching the indication on voltmeter No. 2. Apply sufficient dc to duplicate exactly the indication obtained in the step above.

Note the indication on voltmeter No. 1 which is connected across the d-c supply circuit. Since this voltage was obtained across 1000 ohms, the voltmeter indication is the current in milliamperes. This is I_{dc}.

Determine the power from the formula

$$P = \left(\frac{I_{dc}}{2}\right)^2 R_D \times 1000$$

where R_D is the operating resistance of the r-f detecting thermistor as given on the mount name plate and $\frac{I_{dc}}{2}$ is used to determine r-f power level because the dc applied to the r-f bridge through the D.C. SUBST. terminals divides in the bridge and only half flows through the thermistor.

NOTE

I_{dc} versus mw for commonly-encountered levels of power up to 10 mw are detailed in Table 1.

CONVERSION TABLE FOR EXTERNAL DC

Table 1 supplies power-versus I_{dc} values for both 100-ohm and 200-ohm thermistor mount resistances for commonly-encountered power levels from 0.01 mw to 10 mw. It is necessary to determine power from the mathematical expression given in the preceding paragraph.

P_{rf}	I_{dc} (ma)		P_{rf}	I_{dc} (ma)	
(mw)	R_D = 100	R_D = 200	(mw)	R_D = 100	R_D = 200
10	20.000	14.142	0.5	4.472	3.162
9	18.974	13.416	0.4	4.000	2.828
8	17.889	12.649	0.3	3.464	2.450
7	16.733	11.832	0.2	2.828	2.000
6	15.492	10.954	0.1	2.000	1.414
5	14.142	10.000	0.09	1.897	1.342
4	12.649	8.944	0.08	1.789	1.265
3	10.954	7.746	0.07	1.673	1.183
2	8.944	6.323	0.06	1.549	1.095
1	6.323	4.472	0.05	1.414	1.000
0.9	6.000	4.243	0.04	1.265	0.894
0.8	5.657	4.000	0.03	1.095	0.775
0.7	5.292	3.742	0.02	0.894	0.632
0.6	4.899	3.464	0.01	0.632	0.447

Table 1. Power Versus D-C Current

BATTERY USE AND CHARGING. – To obtain maximum life from the battery avoid discharging or nearly discharging it. When it is necessary to operate from the battery supply for a long period, make certain to charge the battery in the ratio of approximately two charging hours for each operation hour. When the nickel-cadmium battery is fully charged it can supply power for 24 hours of continuous operation, if required. Such a continuous operating period should be followed by a 48-hour charging period.

LOW BATTERY INDICATIONS. – When it is impossible to zero-set or the zero-set is changing rapidly, while operating on battery, it is generally an indication that the battery needs recharging.

CAUTION

Whenever there is an indication of low battery, immediately stop operation and recharge the battery. Damage to the battery may result if it is discharged further or remains discharged.

BATTERY CHARGING. – Use the following procedure to charge the internal battery:

a. Set the line voltage switch (2, Figure 16) for the nominal voltage of the a-c power source.

b. Check that the power cable set is properly plugged into the power input connector (5) and attach the power cable to the a-c source.

c. Set the mode switch (7, Figure 15) to CHARGE. The pilot lamp should light, indicating that the battery is charging.

d. Record the time the battery was placed on charge for future reference.

e. Charge 2 hours for every hour of previous use.

USING SPECIAL FEATURES. – The Microline 66A2 Power Meter-Leveler Amplifier furnishes a current (0 to 1 ma, dc) at the RECORDER jack (5, Figure 16) which is proportional to the power measured. This additional output feature provides a measurement system with much more capability than merely a meter indication of power. Some of the more useful of these measurement systems are illustrated in block diagram form and discussed in the following paragraphs.

Making Permanent Records. Attach the recorder to the measurement system as shown in Figure 19. Although any type of recorder may be used with the power meter, the resistance across the RECORDER (5) output must not exceed 2000 ohms. If the recorder to be used has an input resistance in excess of 2000 ohms, add a shunt across the recorder input.

Obtaining Greater Resolution. The circuit arrangement in Figure 20 will supply direct measurements to three decimal places. An accurate voltmeter, preferably of the digital type having an accuracy of at least 0.2% and a precision resistor (R_X in Figure 20) of 0.1% or better should be used for greatest accuracy. For proper placement of the decimal point in the voltmeter indication, refer to the power meter range switch (2, Figure 15) setting for range in use. The proper value of precision resistor (R_X) to be used on each range of the power meter is listed in Table 2.

Attaching Alarm Actuating Systems. By the addition of a d-c amplifier and a relay circuit to the d-c output (RECORDER jack), as illustrated in Figure 21, this output can be used to actuate alarms or other types of control circuits.

Determining Insertion Gain or Loss-Versus-Frequency. The equipment arrangement shown in Figure 22 can be used to supply data on insertion gain or loss as a function of frequency. Do not connect equipment to be tested into the setup illustrated. Connect thermistor mount directly to the r-f sweep oscillator. Set the sweep oscillator

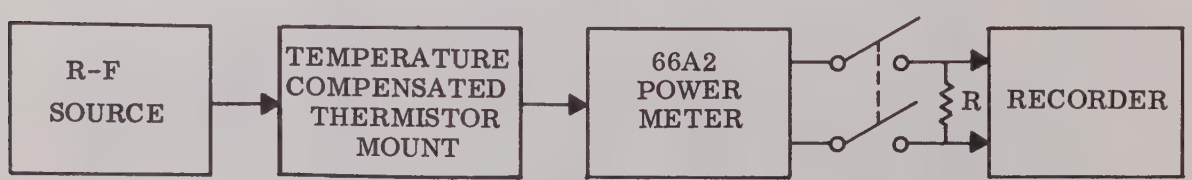


Figure 19. Method of Using a Recorder with the Power Meter

RANGE (mw)	RESISTANCE
0.01	1000
0.03	316.2
0.1	1000
0.3	316.2
1.0	1000
3.0	316.2
10.0	1000

Table 2. Resistor Values for Meter Ranges

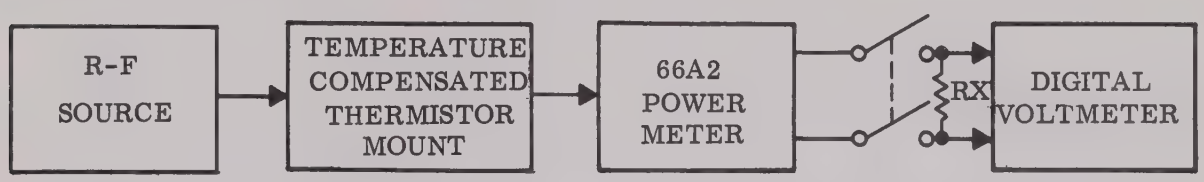


Figure 20. Method of Using a Voltmeter with the Power Meter for Increased Resolution

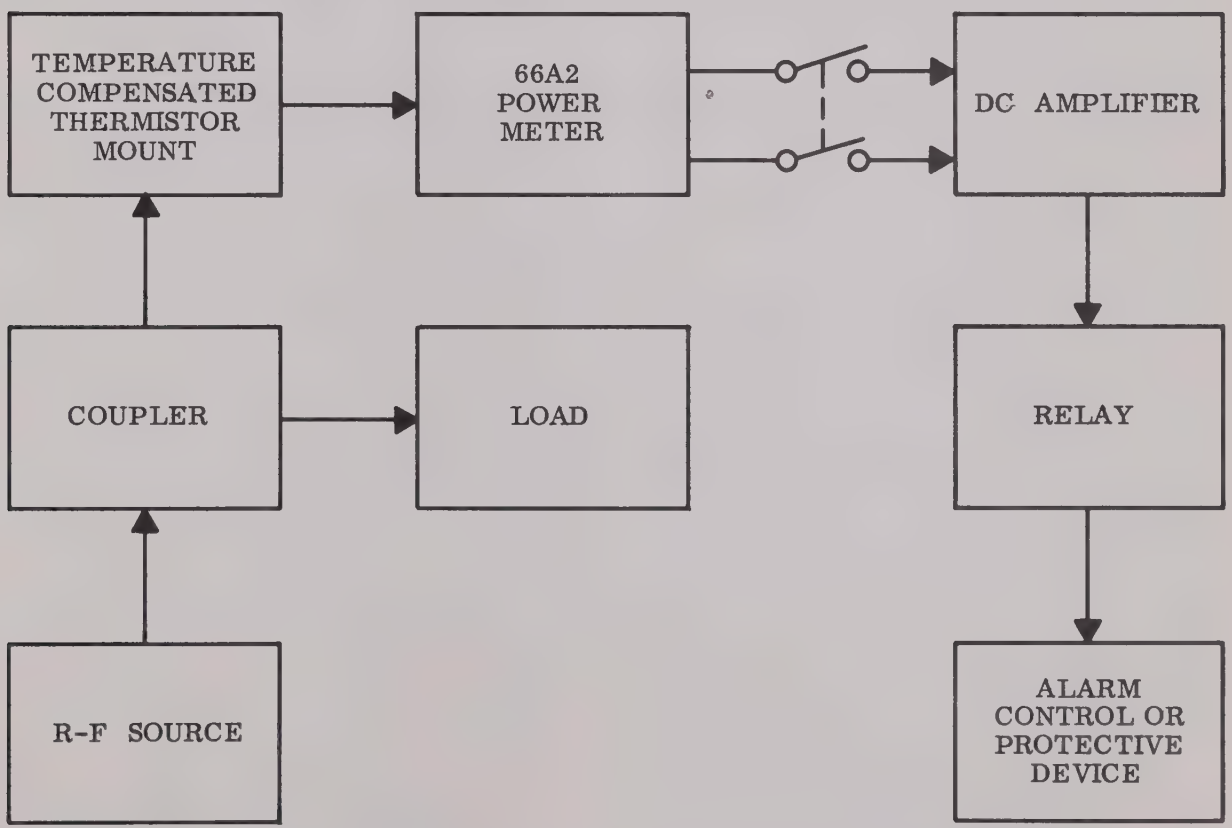


Figure 21. Using the Power Meter for Monitor Control

to the band to be checked and record the amplitude variations as the frequency is swept to obtain a reference curve. Now, insert the equipment to be tested between the sweep oscillator and the thermistor mount and repeat the frequency response measurement. The ratio of this second reading to the previously recorded reference, at any particular frequency, is the insertion gain or loss of the equipment under test at that frequency.

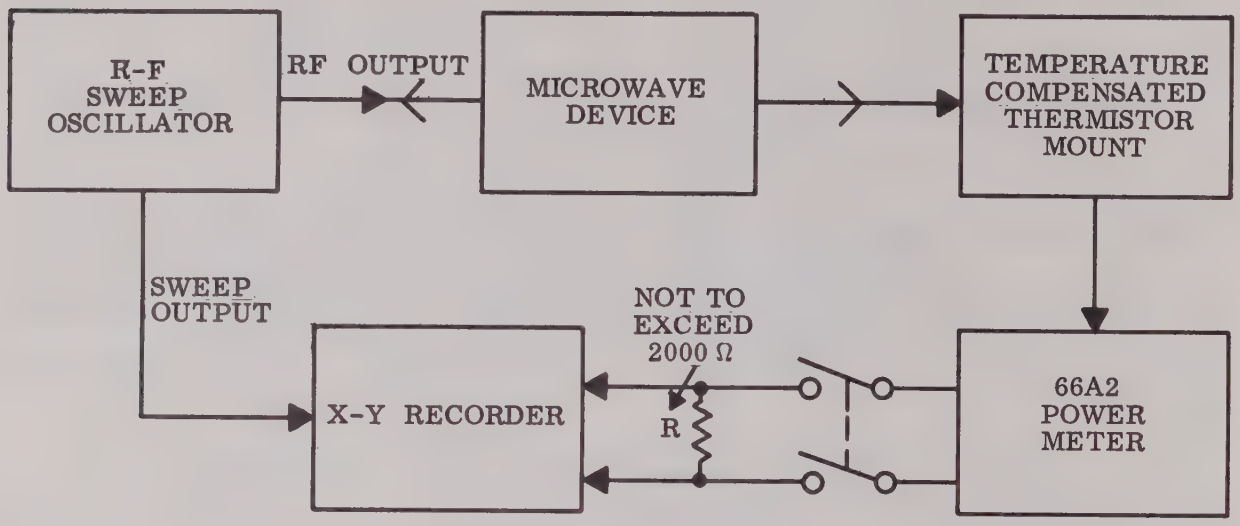


Figure 22. Measurement of Insertion Loss Using the Power Meter

MAINTENANCE AND ADJUSTMENT

GENERAL

This section provides servicing information and instructions for performing maintenance checks, troubleshooting and repair of the Microline 66A2 Power Meter-Leveler Amplifier and its accessory battery.

MECHANICAL ZERO-SETTING OF METER

Proceed as follows to mechanically zero-set the panel meter for best calibration accuracy and mechanical stability.

NOTE

The meter is properly zero-set if the pointer is resting over the zero calibration mark on the meter scale when the power meter is at normal operating temperature, resting in normal operating position, and turned off. When setting the mechanical zero-adjustment, use the mirror on the meter scale to eliminate parallax and increase accuracy of the zero-setting.

a. Follow the operating instructions as outlined in the Operation Section and allow the power meter to remain in operation for a minimum of 20 minutes. This warm-up period will allow the panel meter movement to reach normal operating temperature.

b. Turn the mode selection switch to the OFF position, removing the power. Allow at least 30 seconds for capacitors to discharge before proceeding.

c. Rotate the mechanical zero-setting screw in the clockwise direction until the meter pointer approaches zero as it moves upscale. Set the pointer directly over the zero-calibration line on the meter scale.

d. Turn the zero-set screw in the counter-clockwise direction for approximately 15° to make certain that the screw does not contact any part of the meter movement. Observe any pointer movement.

e. If any meter pointer movement is observed in step d., repeat steps c. and d.

PREPARATION FOR TEST OR REPAIR

Only ordinary shop procedures are required for the disassembly and repair of the power meter.

NOTE

Do not change ground points when replacing parts in the Microline 66A2 Power Meter-Leveler Amplifier. Dress leads and replacement parts to duplicate the original part in order to maintain original circuit balance and performance.

COVER REMOVAL

Routine checks and adjustments can be performed after removal of the cover. Place the power meter on a flat surface, remove the two hold-down screws on each side of the case, and lift the cover off the power meter.

Certain shop operations, such as soldering or replacement of parts, may require the removal of the bottom cover or back panel. To remove the bottom cover, place the power meter in an inverted position on a clean flat surface, remove the nine cover attaching screws, and lift off the bottom cover. Take out the screws, nuts, and washers attaching the back panel to the power meter chassis, when removal of this panel is necessary. Take out nuts holding jacks and binding posts to back panel, to separate panel from chassis.

Test Equipment. The recommended test equipment for testing and troubleshooting the power meter is listed in Table 3. Equivalent test equipment, meeting the specifications presented in this table, may be substituted.

PERFORMANCE TEST PROCEDURE

This procedure verifies the satisfactory operation of the Microline 66A2 Power Meter Leveler Amplifier. It can be used as a quality control check on receipt of a new power meter for routine preventive maintenance checks, and for testing after repair. It is not necessary to remove the cover to perform this procedure.

A thermistor mount must be connected to the power meter during performance testing. These tests are performed without the application of r-f power to the thermistor mount.

NOTE

For accurate results, be sure to shield the thermistor mount if there is any possibility of r-f pickup.

TEST EQUIPMENT	TEST	EQUIPMENT SPECIFICATIONS	RECOMMENDED TEST EQUIPMENT
D-C Voltmeter	D-C voltage measurement and calibration accuracy	Range: 0.5 to 50 volts dc Accuracy: ±0.2% Resolution: three digit	Cubic Corp. digital voltmeter or equivalent
Ohmmeter	Continuity and resistance checks	Range: 1 ohm to 10 megohms Accuracy: 5% of full scale	H-P 410B or equivalent
Precision Milliammeter and Power Supply	D-C Substitution and Calibration	Milliammeter Accuracy; 0.1% of full scale Range: 0 to 30 ma Power Supply Current Accuracy: 0.1% Resistance Accuracy: 0.2%	Sensitive Research Instrument Corp. Model B, Code BAMILEK H-P 711A and 10,000 Ω resistor
Milliammeter	Battery circuit check	Range: 10 to 60 ma Accuracy: 5%	Simpson 260 or equivalent
Oscilloscope	Power supply ripple, 10-kc bias checks Null adjustment	Bandwidth: 10 to 100 kc Accuracy: 5% Input Impedance: 1 meg	Tektronix Model 504
A-C Voltmeter	Power supply ripple, 10-kc bias checks Null adjustment	Accuracy: 5% Input Impedance: 1 meg	Ballantine Model 314
D-C Source or Power Meter Calibrator	Substitution calibration and battery operation check	Range: 0 to 220 vdc or Current Output: 0 to 20 ma	H-P 711A, 721A, 723A or equivalent
Thermistor Mount	Completion of test circuit		Sperry 33X4, 33B4
Transformer to Vary Line Voltage	Power supply regulation check	Voltage Range: 90 to 120 vac 180 to 240 vac Current Rating: 1 amp	General Radio W5MT3A or equivalent
Frequency Counter	10-kc amplifier/ocsillator and 10-kc amplifier checks 10-kc oscillator frequency adjustment	5 place readout Input Sensitivity less than 4 v rms Max. Frequency: greater than 10-kc Accuracy: better than 0.1%	H-P 521C or B or equivalent

Table 3. Recommended Test Equipment

The performance of the power meter is tested by verifying its calibration and range tracking accuracy. The testing is accomplished with the d-c substitution method of measurement (refer to d-c substitution method of precision measurement in the operation section), using an HP Model 711A Power Supply or other equivalent equipment capable of supplying and monitoring precise constant direct currents sufficient to provide full scale deflection on all power meter ranges.

Inspect the mechanical zero-setting of the power meter. Reset the pointer, using the procedure outlined in Mechanical Zero-Setting of Meter in this section.

CALIBRATION AND TRACKING ACCURACY TEST

a. Connect the power supply output terminals to the D.C. SUBST. terminals on the rear of the 66A2 using the series 10K resistor (see Figure 18) and the current measurement equipment.

b. Turn on the 66A2 using the procedure given under the heading A-C Operation in the Operation Section. If a complete check is to be made, zero on the 0.01MW range.

c. Apply d-c current as given in Table 1 for the appropriate range in use.

d. Repeat c. for all ranges. Limits for results are given in Table 4. The 66A2 may be rezeroed or not between ranges.

e. To check the tracking accuracy, use the 10 MW range and apply current for 2 mw, 4 mw, 6 mw and full scale. It is only necessary to check tracking on one scale since the shaping network is common to all ranges.

CAUTION

Do not apply more than 20 ma to the D.C. SUBST. input.

D-C SUBSTITUTION TEST. – Power meter calibration and range tracking accuracy may be tested by use of the d-c substitution method using the equipment and connections illustrated in Figure 18. This method of precision measurement is outlined under the heading D-C Substitution Method of Precision Measurement in the Operation Section. The accuracy of each power range and the tracking accuracy of the 10 mw range may be tested using the input currents and power limits provided in Table 4.

POWER METER ADJUSTMENTS. If any of the following adjustments cannot be satisfactorily performed, or fail to provide the specified results, refer to the troubleshooting procedure and malfunction-cause table in this section.

POWER SUPPLY ADJUSTMENT. – The output level of the -18 volt regulated supply is initially set at the factory, and normally does not require readjustment unless transistor or other component replacement has been made in this circuit. Proceed as follows to adjust the -18 volt supply output potentiometer R83 (see Figure 23 for location of this adjustment):

a. Connect a d-c voltmeter (refer to Table 3 for list of recommended test equipment) between the negative end of capacitor C32 and the power-meter ground.

b. Set the voltmeter for negative readings on the proper scale. Adjust the -18v REG ADJ (R83) for a -18vdc indication on the voltmeter.

TEST POINT MW	INPUT CURRENT (I_{dc}) MA		POWER METER READS MW
	MOUNT RES. 100 OHMS	MOUNT RES. 200 OHMS	
10.0	20.00	14.14	9.7 to 10.3
3.0	10.95	7.75	2.91 to 3.09
1.0	6.32	4.47	0.97 to 1.03
0.3	3.46	2.45	0.291 to 0.309
0.1	2.00	1.41	0.097 to 0.103
0.03	1.10	0.775	0.0291 to 0.0309
0.01	0.632	0.447	0.0097 to 0.0103
8.0	17.89	12.65	7.76 to 8.24
6.0	15.49	10.95	5.82 to 6.18
4.0	12.65	8.94	3.88 to 4.12
2.0	8.94	6.32	1.94 to 2.06

Table 4. Range and Tracking Accuracy Tests

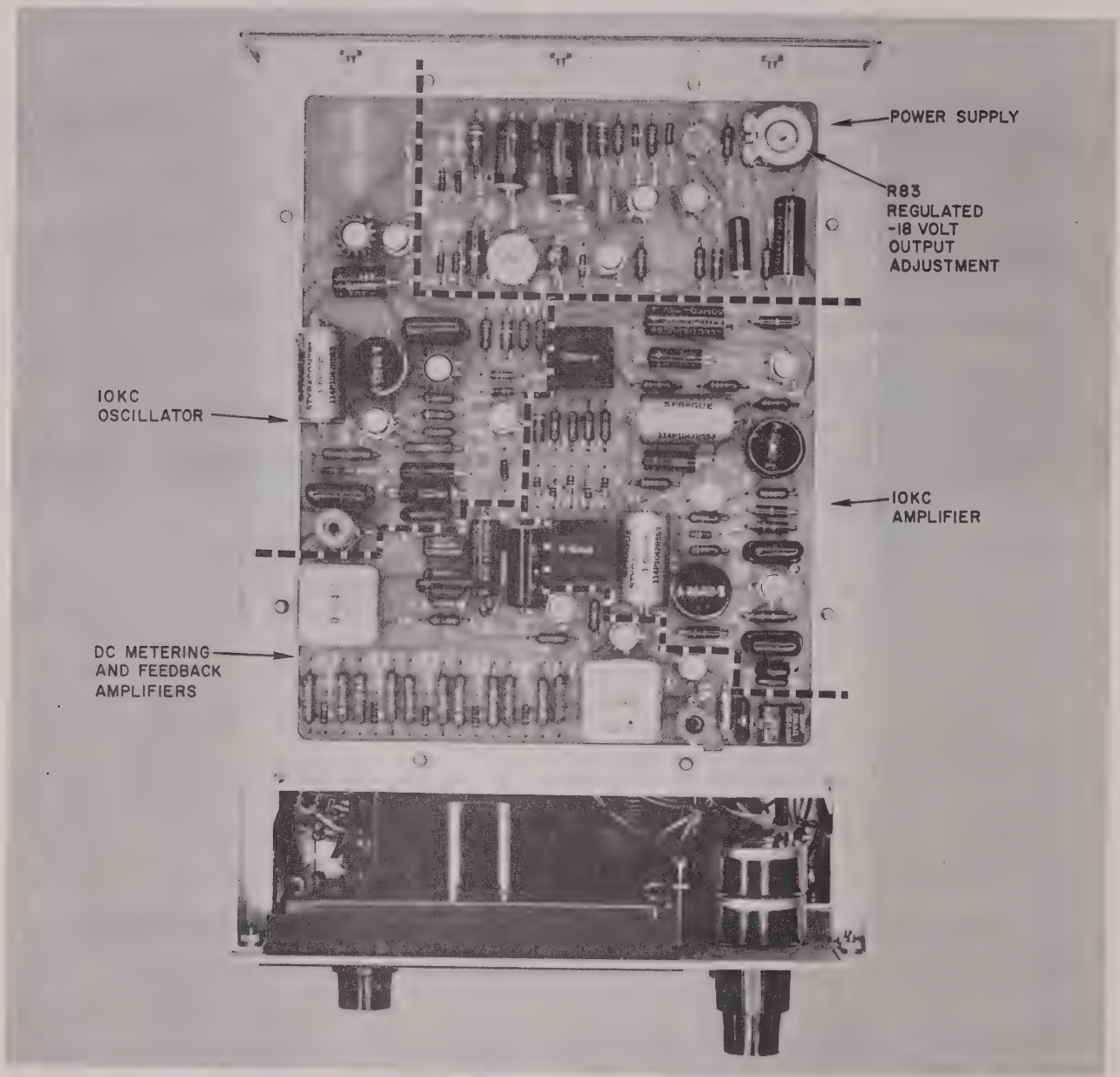


Figure 23. Top View of Microline 66A2 Power Meter-Leveler Amplifier

c. Vary the line voltage through the range from 103 to 127 vac (or 207 through 253 vac). There should not be any noticeable variance in the -18 vdc voltmeter reading.

OSCILLATOR FREQUENCY ADJUSTMENTS. – If 100-ohm and 200-ohm thermistor mounts are to be used interchangeably with the power meter, the following sequence should be used in adjusting the frequency of the 10-kc oscillator. If only one type of mount is to be used with the power meter, only the appropriate adjustment procedure is necessary.

First, perform the 200-ohm mount adjusting procedure outlined in the following paragraph, then perform the 100-ohm mount adjusting procedure. An oscilloscope and a frequency counter (refer to Table 3) are required for these adjustments. Use a plastic alignment tool for the adjustment of coil L5 to avoid core damage.

200-OHM MOUNT ADJUSTING PROCEDURE. – Proceed as follows to adjust the 10-kc oscillator frequency when a 200-ohm thermistor mount is connected to the power meter.

a. Connect a 1800 pf (±1%) capacitor across the r-f input of the coaxial thermistor mount.

b. Attach the thermistor mount and cable to the receptacle and set the ELEMENT RES slide-switch to the 200-ohm position.

c. Connect the frequency counter between the positive end of capacitor C15 and ground. Vary coil L5 to obtain a frequency indication of 10-kc on the counter. (9750 → 10KHz)

d. Connect the oscilloscope between the base of transistor Q1 and ground. Observe the amplitude of the feedback signal. Amplitude should be 5 to 12 mv, peak-to-peak. If a proper amplitude indication is not obtained, refer to the 10-KC Oscillator/Amplifier Tests paragraph later in this section for possible causes.

100-OHM MOUNT ADJUSTING PROCEDURE. – Proceed as follows to adjust the 10-kc oscillator when a 100-ohm thermistor mount is connected to the power meter.

a. Attach the 100-ohm thermistor mount and cable to the receptacle. Set the ELEMENT RES slide-switch to the 100-ohm position.

b. Connect the frequency counter between the positive end of capacitor C15 and ground. The oscillator frequency indicated on the counter should be 10-kc ±50 cps. If the oscillator frequency is not within this specified limit, proceed with step c., below.

c. Substitute other values of capacitance for C1, observing the indications of the frequency counter, until the oscillator frequency is within 10-kc ±50 cps.

d. Connect the oscilloscope between the base of transistor Q1 and ground. Observe the amplitude of the feedback signal. Amplitude should be 3 to 8 mv peak-to-peak. If the proper amplitude is not obtained, refer to the paragraph entitled 10-KC Oscillator/Amplifier Tests in this section for possible causes.

NULL ADJUSTMENT

If the 100-ohm and 200-ohm thermistor mounts are to be used interchangeably with the power meter, a coarse null adjustment should be performed in the following sequence. The 200-ohm mount null adjusting procedure should be performed first, as outlined below. Then perform the 100-ohm null adjusting procedure given in a following paragraph.

If only the accessory 200-ohm thermistor mounts are to be used with the power meter, the procedure outlined in the following paragraph should be followed. Perform the separate 100-ohm mount null adjusting procedure when only a 100-ohm mount is to be used with the power meter. An oscilloscope or vacuum-tube voltmeter (refer to Table 3) is required for performing any of these null adjustment procedures. Use a plastic alignment tool for the adjustment of coil L6 to avoid core damage.

200-OHM MOUNT NULL ADJUSTING PROCEDURE.

Proceed as follows to make a coarse null adjustment, when the power meter is to be used with 200-ohm thermistor mount.

a. Connect a 1800 pf (±1%) capacitor across the r-f input of the thermistor mount.

b. Attach the thermistor mount and cable to the receptacle and set the ELEMENT RES slide-switch to the 200-ohm position.

c. After the power meter has warmed up, adjust the ZERO control for an on-scale indication of the panel meter with the range selection switch set to the 10-MW position.

d. Set nulling capacitor C3 to the center of its operating range.

e. Connect one side of the oscilloscope or vacuum-tube voltmeter to the lead of fixed resistor R63 nearest T3. Connect the other side of the

oscilloscope or meter to ground. Adjust coil L6 to obtain a minimum indication on the test equipment.

f. Move the range selection switch to the .01 MW position and adjust the ZERO control knobs for an approximate midscale indication on the panel meter.

g. Move the range selection switch to the NULL position. Adjust nulling capacitor C3 for a minimum reading on the panel meter. This minimum reading should be less than 15% of full scale, and C3 should be near the middle of its operating range.

100-OHM NULL ADJUSTING PROCEDURE. – Proceed as follows to make a coarse null adjustment if a 100-ohm thermistor mount is also to be used with the power meter.

a. Attach the 100-ohm thermistor mount and cable to the receptacle. Set the ELEMENT RES slide-switch to the 100-ohm position.

b. After the power meter has warmed up, adjust the ZERO control for an on-scale indication of the panel meter with the range selection switch set to the 10 MW position.

c. Set nulling capacitor C3 to the center of its operating range.

d. Connect one side of the oscilloscope or vacuum-tube voltmeter to the lead of fixed resistor R63 nearest T3. Connect other side ofoscilloscope or meter to ground.

e. Replace C6 with other selected values of capacitance to obtain a minimum reading on the test equipment.

f. If the capacitance of C6 is reduced to zero without obtaining a null indication, it will be necessary to, first, replace C4 with a capacitor of less value, and second, to repeat the 200-ohm mount null adjusting procedure given in the preceeding paragraph for a minimum setting of L6. Then repeat steps a. through e., above.

g. Move the range selection switch to the .01 MW position, and adjust the ZERO control knobs for an approximate midscale indication on the panel meter.

h. Move the range selection switch to the NULL position. Adjust nulling capacitor C3 for a minimum reading on panel meter. This minimum reading should be less than 15% of full scale, and C3 should be near the middle of its operating range.

SEPARATE 100-OHM MOUNT NULL ADJUSTING PROCEDURE. – The following procedure is to be used for making a coarse null adjustment when only a 100-ohm thermistor mount is to be used with the power meter.

NOTE

Before use of the power meter with a 200-ohm thermistor mount, the instructions in the 200-ohm Mount Null Adjusting Procedure should be followed.

a. Perform steps a., b., c., and d. of the preceeding paragraph (100-Ohm Null Adjusting Procedure).

b. Adjust coil L6 to obtain a minimum indication on the test equipment.

c. If the adjustment of L6 fails to provide a null indication, center the core in L6, then replace C6 with other selected values of capacitance until a null indication is obtained. Next, readjust coil L6 to improve the null indication.

d. Move the range selection switch to the .01 MW position, and adjust the ZERO control knobs for an approximate midscale indication on the panel meter.

e. Move the range selection switch to the NULL position. Adjust nulling capacitor C3 for a minimum reading on panel meter. This minimum reading should be less than 15% of full scale, and C3 should be near the middle of its operating range.

TROUBLESHOOTING AND REPAIR

When there is an indication of trouble in the power meter, the thermistor mount and cable in use should first be checked to isolate the malfunction to the power meter.

Check the thermistor mount, using the operating information supplied with the mount. If the mount in use is defective, replace it with a known-good mount and return the power meter to use. Check the continuity of the thermistor mount cable conductors and examine the cable connectors. Repair or replace cable, if found defective.

Trouble in the power meter is reflected by lack of, or improper, panel meter indication. Refer to Table 5 where probable causes of improper panel meter indications are listed. When necessary to remove the part listed in this table for test or inspection, follow the repair instructions included in this section of the manual.

In addition to Table 5, the following test procedures will assist in determining the malfunctioning section of the power meter. For purposes of isolating a malfunction, the power meter is divided into five circuit sections. These are Power Supply,

MALFUNCTION ISOLATION	PROBABLE CAUSE
1. Meter pointer clamps upscale from zero.	Defective Q11, Q10 Meter mechanical zero off-set
2. Meter pointer stays down scale.	Defective Q9 Defective R9 Large unbalance in Metering Bridge Thermistor Thermistor Mount Thermistor Mount Cable Defective Q7
3. Meter pointer stays upscale.	Oscillator failure Thermistor Mount Cable Large unbalance in Metering Bridge
4. Meter pointer drifts during readings.	Thermistor mount Defective Q7, Q11 Thermistor mount in unstable thermal environment R-f source unstable D-C calibration/substitution source unstable Power Supply Oscillator/Amplifier 10-kc Amplifier
5. Meter does not indicate, does not zero, but does null.	Defective Q11
6. Meter pointer fluctuates when indicating power on the .01 mw range.	Thermistor mount Thermistor mount cable Noise generated in: Oscillator-Amplifier, Power Supply, 10-kc Amplifier
7. Operation of the ZERO/vernier control results in erratic movement of the meter pointer on the .01 mw range.	Defective ZERO dual potentiometer
8. Movement of the thermistor mount cable causes erratic movement of the meter pointer on the .01 mw range.	Thermistor mount Thermistor mount cable Loose connection between cable plugs and thermistor mount or Power Meter sockets
9. Meter pointer clamps when switching up range after zero set on the .01 mw range.	Defective Q7
10. Meter pointer does not clamp.	Defective CR8 Defective Q10
11. Will not null.	Element RES switch position incorrect Line voltage switch position incorrect Meter pointer has clamped. Repeat zero set procedure Thermistor mount Thermistor mount cable Element RES switch T2 R4 or R5
12. Calibration accuracy not within specification, all power ranges.	Thermistor mount in strong r-f field Interference from stray 10-kc signal Thermistor mount

Table 5. Power Meter Malfunctions and Probable Causes (Sheet 1 of 2)

MALFUNCTION ISOLATION	PROBABLE CAUSE
12. Calibration accuracy not within specification, all power ranges (Cont'd)	Meter not mechanically zero set Meter Element RES switch Power Supply Battery Defective Q7, Q11 Squaring circuit section 10-kc Amplifier
13. Calibration accuracy not within specification, NOT all power ranges	Defective Q7 emitter resistor Defective Q7
14. Range tracking is inaccurate, but calibration accuracy is satisfactory	Defect in Squaring Circuit section
15. R73 overheats or fails	Q3 shorted Q4 shorted
16. Leveler output will not reach 68 volts	External circuit resistance too low Q203 defective
17. Leveler control will not cover proper range	R19 defective Resistance in external recorder circuit too low R208 defective Q201, Q202 defective

Table 5. Power Meter Malfunctions and Probable Causes (Sheet 2 of 2)

TEST POINT	D-C VOLTAGE LIMITS	CHECK
Negative end of C28	-38 to -41	A-C line voltage C28, CR10, CR13
Negative end of C29	-24 to -26	A-C line voltage C29, CR11, CR12, battery
Anode of CR15	-10.7 to -12.3	CR15
Anode of CR14	-6.1 to -7.5	CR14, Q14
Negative end of C32	-18	R83, Q16, Q13
Base of Q12	-18.3 to -18.6	Q13, Q12, Q14, CR14
Anode of CR16	-24.1 to -25.5	CR16, POWER switch
Positive end of C28	+0.7 to +1.4	R73

Table 6. Power Supply Tests

Oscillator/Amplifier and R-F Bridge, 10-KC Amplifier and Metering Bridge, D-C Metering and Feedback Amplifiers, and the squaring circuit section. A thermistor mount must be connected to the power meter when performing the tests for each of these circuit sections.

POWER SUPPLY TESTS

Note the location of the power supply as indicated in Figure 23. The schematic diagram is shown in Figure 26. Attach a d-c voltmeter (refer to recommended list of test equipment, Table 3) between the negative end of capacitor C32 and the power-meter ground. Voltmeter indication should be -18 vdc. Refer to the Power Supply Adjustment instructions in a preceeding paragraph and adjust potentiometer R83 as necessary to obtain the proper indication. If potentiometer adjustment will not provide the -18 vdc indication, proceed in accordance with step a. When the proper -18 vdc indication is obtained, proceed as outlined in step b.

a. If the normal -18 vdc cannot be obtained by adjustment of R83, or if the regulation test outlined in step b. does not produce satisfactory results, connect the d-c voltmeter between the test points listed in the first column of Table 6 and the power meter ground. If the d-c voltages are not within the specified limits at any of these test points, check the parts listed in the table. Replace parts found to be marginal or defective. Voltages at these test points are applicable for both ac and battery power.

b. With the d-c voltmeter attached as instructed above, proceed to test the regulation of the power supply. Use a-c primary power and vary the line voltage through the range of −10% to +10% of the nominal 115- or 230-volt primary power in use. There should not be any noticeable variance in the −18 vdc indication on the voltmeter.

c. Check the ripple voltages for a-c operation using an oscilloscope or a-c voltmeter (refer to Table 3) connected between the test points listed in Table 7 and ground. Check the listed parts if the ripple voltages are not within the limits specified in the table.

10-KC OSCILLATOR/AMPLIFIER TESTS

Note the location of the oscillator/amplifier as indicated in Figure 23 and refer to the schematic diagram of this circuit. A d-c voltmeter, an a-c voltmeter or an oscilloscope, and a frequency counter (refer to Table 3) are required for these tests. The oscillator/amplifier is operating properly if it meets the requirements given in the following paragraphs. If a 200-ohm accessory thermistor mount is used, terminate the r-f imput to the mount with a 50-ohm resistance. This terminating resistance is not required is a 100-ohm thermistor mount is used with the power meter.

Attach the frequency counter between the positive end of capacitor C15 and ground. The oscillator/amplifier frequency should be 9850 ±50 cps when a 200-ohm mount is connected to the power meter. When a 100-ohm mount is connected, the oscillator/amplifier frequency should be 10-kc ±50 cps.

Connect the oscilloscope between the positive end of capacitor C15 and ground to check the output amplitude and waveform. When a 200-ohm thermistor mount is attached to the power meter the output amplitude should be 16.4 vac ±10% peak-to-peak. When a 100-ohm mount is attached to the power meter, the output amplitude should be 7.4 vac ±10% peak-to-peak. The waveform should be sinusoidal, with only a slight amount of crossover distortion caused by Q3 and Q4. If Q3 and Q4 have been replaced, check the output amplitude of the 10-kc Oscillator/Amplifier in accordance with this paragraph.

Connect the oscilloscope between the base of transistor Q1 and ground, and test the amplitude of the feedback signal. This signal shall be between 5 and 12 mv peak-to-peak. If it is not within this limit, the 10-kc oscillator gain is incorrect. Check Q1, Q2, C14, L1, and T1 to determine the cause. If either Q1 or Q2 is replaced, recheck the oscillator frequency and the feedback signal amplitude as specified in this paragraph. The oscillator frequency may require readjustment, if either (or both) L1 or C14 is replaced. Refer to the Oscillator Frequency Adjustments paragraph for the Adjustment Prodedure.

As a further aid in localizing a malfunction within the oscillator/amplifier, perform the d-c measurements listed in Table 8. In the event the presence of the 10-kc signal interferes with these measurements, the 10-kc oscillator may be disabled by grounding the Q2 collector terminal. Deactivating the oscillator will not have any appreciable effect on the d-c voltages measured at the test points listed in the first column of Table 8. The voltages are measured with the d-c voltmeter connected between the test points and the power meter ground.

RIPPLE VOLTAGE LIMITS			
TEST POINT	**RMS**	**PEAK-TO-PEAK**	**CHECK**
Negative end of C28	2.1 v max.	6 v max.	CR10, CR13, C28
Negative end of C29	2.1 v max.	6 v max.	CR11, CR12, C29, C32, Q13
Negative end of C32	10.6 mv max.	30 mv max.	Q12 through Q16, CR14, CR15, C29, C32

Table 7. Power Supply Ripple Voltage Tests

TEST POINT	D-C VOLTAGE LIMITS	CHECK
Collector of Q3	-18	Power Supply
Emitter of Q2	-11.0 to -15.0	C11, C12, CR1, Q1, Q2
Negative end of C11	-6.1 to -7.5	C11, CR1, Q1

Table 8. Oscillator/Amplifier Voltage Tests

10-KC AMPLIFIER TESTS

Note the location of the 10-kc amplifier as indicated in Figure 23. A d-c voltmeter and an oscilloscope (refer to Table 3) are required for these tests.

To isolate any malfunction in the 10-kc amplifier, use the d-c voltmeter to make voltage tests between the test points listed in Table 9 and ground. D-c voltages should be within the limits specified in this table. If any voltage is outside the limit, check the parts listed opposite the voltage limit. In the event the presence of the 10-kc signal interferes with these measurements, connect the center-tap of coil L6 directly to ground. Do not ground this tap when making any a-c tests.

A-c operation of the amplifier may be checked by a-c signal tracing with an oscilloscope. Setting of ZERO controls will not have much effect on 10-kc amplitude as long as the panel meter is on-scale. If the ZERO adjustment is made to deflect the meter downscale, below zero, 10-kc amplitude may be controlled with the ZERO controls. When making signal checks in this manner, do not use excessive 10-kc signal and overload the amplifier or gain checking will be difficult.

D-C METERING AND FEEDBACK AMPLIFIER TESTS

Note the location of the d-c metering and feedback amplifier (see Figure 23). Using a digital or a d-c voltmeter, check the d-c voltages between the test points listed in Table 10 and ground. If any voltage is outside the specified limits, test the listed parts.

If malfunction in these stages is due to excessive leakage in Q7 or Q11, the defective transistor may be detected as follows:

WARNING

If a VTVM is used, be certain that the ground (or negative) lead is not connected to the case and possibly back to the power line ground. Many VTVM units have this connection and cannot be used for "floating" measurements such as this one.

TEST POINT	D-C VOLTAGE LIMITS	CHECK
Anode of CR2	-6.1 to -7.5	C16, CR2, R41, R43, R45, C17
Emitter of Q5	-1.74 to -2.43	Q5, C17, R41, R43, R44
Negative end of C21	-4.1 to -7.0	C21, Q6, Q8

Table 9. 10-KC Amplifier Voltage Tests

TEST POINT	D-C VOLTAGE LIMITS	CHECK
Junction of R64 - R65	-24.1 to -25.5	-18 v Power Supply, CR16
Base of Q9	-0.1 to -0.4	C22, C23, CR3 through CR6, Q9
Emitter of Q7	-4 to -18	-18 v at range switch S2, switch resistors R20 through R26, Q7, Q9

Table 10. Metering-Feedback Amplifier Voltage Tests

a. Turn the ZERO controls max CCW (meter reading downscale below zero).

b. Put negative lead of voltmeter on -18 volt supply.

c. Measure the voltage drop from the -18 volt supply to the emitter of Q7 or Q11. It should be zero. If it is positive, excessive reverse base-emitter leakage is indicated. If it is negative, excessive forward leakage is indicated.

SQUARING CIRCUIT SECTION TESTS

Refer to the schematic. This circuit section should be tested if the power meter does not meet the calibration or tracking specifications. Use a digital voltmeter (refer to Table 3 for list of recommended test equipment) to make the d-c voltage measurements at the test points listed in both parts of Table 11.

Table 11 lists the limits of the d-c voltages at the test points when all diodes are conducting. Table 11 lists the limits when all diodes are nonconducting. When the squaring circuit section is tested, both sets of voltages should be checked to insure that the section is operating satisfactorily.

Set the range selection switch to the 1 MW position, and adjust the ZERO controls to obtain an exact full-scale deflection on the panel meter. Connect the digital voltmeter across the diodes as listed in the first portion of Table 11 (diode conducting). Voltages should be within the limits listed in the table. If any voltage is outside the voltage limit, check the diode across which the test was made. The voltmeter input must be floating for these tests.

Next, test the circuit section with the diodes nonconducting. To perform these tests rotate the ZERO control counter-clockwise until the panel-meter pointer clamps below zero. Connect the voltmeter between the side of each of the diodes listed in Table 11 and ground.

The test points shown in the last portion of Table 11 (diodes nonconducting) are midpoints of five dual-resistor voltage dividers connected between the -18 vdc and ground. This nonconducting diode test insures that each diode is properly back-biased, and that transistor Q11 is not conducting.

Check that the d-c voltage at the test points are within the limits specified in Table 11. If any voltage is outside the limit, test the parts shown opposite that voltage in the table and replace any part found to be marginal or defective.

LEVELER AMPLIFIER TESTS

The following tests will check operation of the leveler amplifier. All tests are made with a thermistor mount connected and no external connection to the LEVELER OUT jack (J6).

a. With the power meter zeroed, turn the LEVEL control to the maximum CCW position until the switch operates. A voltmeter should show +62 to +75 volts d-c to ground at J6.

b. Turn the LEVEL control clockwise until the switch JUST operates. The voltage at J6 should fall to about -10 volts.

c. Advance the ZERO control to cause the meter to read upscale. At about 0.3 full scale, the voltage at J6 should swing up to about +68 volts.

d. Set the meter indication to full scale with the ZERO controls and advance the LEVEL control. At a point near maximum clockwise rotation, the output voltage at J6 should fall to about -10 volts. If it does not fall back before maximum clockwise rotation is reached, insufficient bias range at the base of Q20 is indicated.

REPAIRING THE POWER METER

As with any transistorized instrument, soldering irons for repair work must be selected to avoid application of excessive stray voltage or power line leakage to the circuit. Failure to observe this precaution may result in damage to semiconductor components on the board.

Transformers T1, T2, T3, and T4 may be replaced; however, selected value capacitors C1 and C6 may require reselection. Refer to instructions given in the Oscillator Frequency and Mount Adjustment paragraphs.

CAUTION

Use a heat sink when replacing any transistor, to avoid damage to the transistor during soldering.

Proceed as follows to remove and replace component parts on the circuit board assembly. Do not apply excessive heat to the circuit board assembly.

a. Clip the defective component leads near the component and remove it from the board assembly.

b. Apply heat and detach the lead with a straight upward motion.

c. To remove components having several connections, melt the solder at each connection and keep it molten while working the component from the board.

TEST POINT	D-C VOLTAGE LIMITS	CHECK
(A) DIODES CONDUCTING		
Across CR18	0.44 to 0.6	–
Across CR19	0.43 to 0.6	–
Across CR20	0.41 to 0.58	–
Across CR21	0.40 to 0.55	–
Across CR22	0.36 to 0.52	–
(B) DIODES NONCONDUCTING		
Anode CR18	-17 to -18	CR18 through CR22
Cathode CR18	-16.3 to -16.6	CR18, R91, R96
Cathode CR19	-14.3 to -14.6	CR19, R92, R97
Cathode CR20	-12.3 to -12.6	CR20, R93, R98
Cathode CR21	-10.2 to -10.6	CR21, R94, R99
Cathode CR22	-8.2 to -8.5	CR22, R95, R100

Table 11. Squaring Circuit Voltage Tests

d. When mounting the new component on the board, take care to clear the hole in the board and conductor for the component lead before inserting the lead into the hole. Avoid pressure on the plated conductor which might tend to separate it from the board.

BATTERY TESTS

Installation and use instructions for the accessory nickel-cadmium battery are provided in the Operation Section of this manual. After any extensive storage period the battery should be fully recharged prior to use. The battery cells are sealed and do not require the addition of any liquid.

A milliammeter, a d-c voltmeter (refer to Table 3), a 7500-ohm, 2-watt resistor, and a 780-ohm, 3-watt resistor are needed for testing the battery. Disconnect the a-c power line. Proceed as follows to test the battery.

a. Attach the d-c voltmeter between the B- terminal on the circuit board assembly and the power meter ground. Set the mode selection switch to the BATT position. The battery voltage, observed on the d-c voltmeter, should be -24 to -27 volts.

b. Set the mode selection switch to the OFF position. Disconnect the lead from either the B+ or the B- terminal of the circuit board assembly. Connect the milliammeter in series with the disconnected lead and the circuit board terminal from which the lead was removed. Set the mode selection switch to BATT and observe the current drain. The milliammeter indication should be between 40 ma and 53 ma. On completion of the test reconnect the removed lead.

BATTERY CHARGING CIRCUIT TEST. – Proceed as follows to test the battery charging circuit of the power meter.

a. Set the mode selection switch to OFF. Connect the power meter to the a-c line. Disconnect both leads of the battery from the circuit board assembly.

b. Place the 780-ohm resistor in series with the milliammeter, and attach the resistor and meter across the battery terminals on the circuit board assembly.

c. Set the mode selection switch to CHARGE. Measure the charging current regularly supplied to the battery. The meter indication should be between 32 ma and 40 ma. Set the switch to the OFF position.

d. Remove the 780-ohm resistor and place the 7500-ohm resistor in series with the milliammeter. Place the meter and resistor across the circuit board battery terminals.

e. Move the mode selection switch to the AC position and measure the trickle charging current regularly supplied to the battery. The meter indication should be between 3.2 ma and 4.8 ma. Reconnect the battery leads to the proper terminals on the circuit board assembly.

THERMISTOR REPLACEMENT

a. To replace the thermistors in the 33X4 Thermistor Mount remove the two screws (1, Figure 24) and cover (2) and loosen screws (3). Remove the two screws (4) and separate housing and waveguide assembly (5) using care to avoid breaking conductors (6). Disengage but do not remove screws (7) and remove conductor assembly (8). Replace thermistors (9) and reassemble the thermistor mount with the conductor from P1-1 (red) adjacent to the waveguide flance. Use care to insure alignment of supports (10). Tighten screws (3) and replace cover (2) and housing (5).

b. To replace the thermistors in the 33B4 Thermistor Mount remove the three screws (1, Figure 25) and separate knob and housing (2) using care to avoid breaking conductors (3). Disengage but do not remove screws (4) and remove plate (6) and rear thermistor (9). Disengage screws (7) and remove mounting assembly (8). Replace thermistors (9) on the guide pins of contact plates (6) and (10) using care to avoid breaking the thermistor elements. Reassemble the thermistor mount with the clearance hole of the mounting plate assembly (8) aligned with the tapped hole of the front contact plate (10) and the longer of the two screws (4). Use care and tighten screws (7) and screws (4) uniformly to insure proper seating of thermistors and front and rear contact plates. Reassemble knob and housing and replace screws (1).

CAUTION

Do not attempt disassembly beyond that above. Damage to the mount may result.

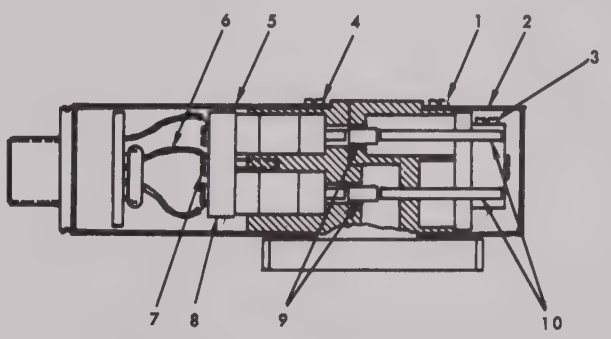


Figure 24. 33X4 Thermistor Mount

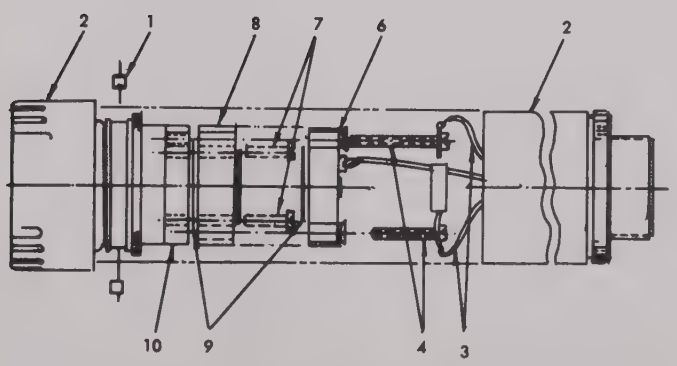


Figure 25. 33B4 Thermistor Mount

REPLACEABLE PARTS LIST

GENERAL.

This section provides a listing of the replaceable parts of the Model 66A2 Power Meter. The listing contains the necessary information for the ordering of replacement parts. Parts are listed in alpha-numerical order of their reference designators in accordance with the designators assigned to these parts in the schematic diagrams included in this manual. Part nomenclature, with descriptive data for ordering purposes, are provided along with the Sperry part number of each part.

To facilitate ordering of replacement, parts are referenced to the selected list of manufacturers given below. A manufacturer's code number is included in the parts list for this purpose. The total quantity of each part installed in the power meter is also shown in the parts list.

MANUFACTURER'S CODE

(Code to Name)

MFR. FED. SUPPLY CODE	NAME	ADDRESS
00656	Aerovox Corp.	New Bedford, Mass.
01121	Allen-Bradley Co.	Milwaukee 4, Wis.
01295	Texas Instruments, Inc.	Dallas,Texas
01807	Peterson Radio Co.	Council Bluffs, Iowa
02567	International Electronic Industries, Inc.	Nashville, Tenn.
02660	Amphenol Electronics Corporation	Chicago 50, Illinois
02735	RCA	Somerville, N.J.
03045	Ortho Filter Corp.	Paterson, N.J.
03797	Eldema Corporation	El Monte, Calif.
04009	Arrow, Hart & Hegeman Electric Co.	Hartford, Conn.
04221	Aemco, Inc.	Mankato, Minn.
04222	Hi-Q Division of Aerovox Corp.	Myrtle Beach, S.C.
04941	Walsco Electronics Corp.	Rockford, Ill.
05624	Barber-Colman Co.	Rockford, Ill.
06424	Sperry Microwave Electronics Co.	Clearwater, Fla.
06486	North American Electronics, Inc.	Lynn, Mass.
06555	Beede Electrical Instrument Co.	Penacook, N.H.
07065	Line Electric Co.	Newark, N.J.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07115	Corning Glass Works	Bradford, Pa.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07387	Birtcher Corporation	North Los Angeles, Calif.
07688	Joint Electronic Tube Council (Jetec)	Washington, D.C.
08717	Sloan Co.	Burbank, Calif.
08914	Florida Transformer Co.	De Leon Spring, Fla.
09250	Electro Assemblies, Inc.	Chicago, Ill.
11903	MEC, Inc.	Nashville, Tenn.
12674	Synchro Corp.	Hicksville, Ohio
12697	Clarostat Mfg. Co.	Dover, N.H.
13664	Workman Electronics	Sarasota, Fla.
14193	California Resistor Corp.	Santa Monica, Calif.
15915	Tepro of Florida	Dunedin, Fla.

MANUFACTURER'S CODE (Continued)

(Code to Name)

19701	Electra Mfg. Co.	Kansas City, Mo.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
33173	General Electric Co.	Owensboro, Ky.
42190	Muter Company	Chicago 5, Ill.
46859	Philco Corp.	Lansdale, Pa.
55933	Sonotone Corp.	Elmsford, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
58474	Superior Electric Co.	Bristol, Conn.
60437	Tower Mfg. Co.	Providence 3, R.I.
61577	Ultronix, Inc.	San Mateo, Calif.
65092	Daystrom Corp.	Newark, N.J.
70119	Advance Electric and Relay Co.	Burbank, Calif.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago 44, Ill.
71002	Birnbach Radio Co.	New York 13, N.Y.
71218	Bud Radio, Inc.	Cleveland, Ohio
71400	Bussman Mfg. Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71590	Centralab Civ. Globe Union, Inc.	Milwaukee 1, Wis.
71785	Cinch Mfg. Co.	Chicago 24, Ill.
72136	Electro Motive Mfg. Co.	Willimantic, Conn.
72259	Essex Electronics, Inc.	Berkley Heights, N.J.
72619	Dialight Corp.	Brooklyn 37, N.Y.
72765	Drake Mfg. Co.	Chicago 22, Ill.
72825	Hugh H. Eby, Inc.	Philadelphia, Pa.
72982	Erie Resistor Corp.	Erie 6, Pa.
73293	Hughes Products, Div. Hughes Aircraft Co.	Los Angeles, Calif.
73445	Amperex Electronics Corp.	Hicksville, N.Y.
74042	Merit Coil & Transformer Corp.	Hollywood, Fla.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	St. Petersburg, Fla.
75382	Kulka Electric Mfg. Co., Inc.	Mt. Vernon, N.Y.
75915	Littelfuse, Inc.	Des Plaines, Ill.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76854	Oak Mfg. Co.	Chicago 10, Ill.
77342	Potter and Brumfield, Inc.	Princeton, Ind.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
79142	Veeder-Root, Inc.	Hartford, Conn.
80131	Electronic Industries Associates	Washington, D.C.
80207	Unimax Switch Div., W.L. Maxon Corp.	Wallingford, Conn.
80486	All Star Products, Inc.	Defiance, Ohio
80583	Hammarlund Co., Inc.	New York 1, N.Y.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Electronics, Inc.	Norwalk, Conn.
81349	Military Specifications (MIL)	
81350	Joint Army-Navy Specifications (JAN)	
81483	International Rectifier Corp.	El Segundo, Calif.

MANUFACTURER'S CODE (Continued)

(Code to Name)

81751	Columbus Electronics	Yonkers, N.Y.
82219	Sylvania Electronic Products, Inc.	Emporium, Pa.
82376	Astron Corp.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago 22, Ill.
82877	Rotron Mfg. Co., Inc.	Woodstock, N.Y.
83330	Herman H. Smith, Inc.	Brooklyn, N.Y.
84411	Good All Electric Mfg. Co.	Ogallalla, Nebr.
86684	R.C.A. Tube Division	Harrison, N.J.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88419	Cornell-Dubilier Electric Corp.	Indianapolis, Ind.
91418	Radio Materials Co.	Chicago, Ill.
91459	Alcon Metal Products, Inc.	Chicago, Ill.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91737	Gremar Mfg. Co., Inc.	Wakefiled, Mass.
91802	Industrial Devices, Inc.	Edgewater, N.J.
93459	Weinschel Engineering Co.	Kensington, Md.
94154	Tung-Sol Electric, Inc.	Newark 4, N.J.
94990	Motorola, Inc.	Phoenix, Ariz.
95712	Dage Electric Co., Inc.	Beech Grove, Ind.
96253	Transformer Technician, Inc.	Chicago, Ill.
96906	Military Standards (MS)	
98687	Raytheon Mfg. Co.	Wayland, Mass
99120	Plastic Capacitors, Inc.	Chicago, Ill.
0000A	United International Dynamics Corp.	Waltham, Mass.

MANUFACTURER'S CODE

(Name to Code)

NAME	CODE
Advance Electric and Relay Co., Burbank, Calif.	70119
Aemco, Inc., Mankato, Minn.	04221
Aerovox Corp., New Bedford, Mass	00656
Alcon Metal Products, Inc., Chicago, Ill.	91459
All Star Products, Inc., Defiance, Ohio	80486
Allen-Bradley Co., Milwaukee 4, Wis.	01121
Amperex Electronic Corp., Hicksville, N.Y.	73445
Amperite Co., New York, N.Y.	70563
Amphenol Electronics Corporation, Chicago 50, Ill.	02660
Arrow, Hart, and Hegeman Electric Co., Hartford, Conn.	04009
Astron Corporation, East Newark, N.J.	82376
Atlantic India Rubber Works, Inc., Chicago, Ill.	70485
Barber-Colman Co., Rockford, Ill.	05624
Beede Electrical Instrument Co., Penacook, N.H.	06555
Belden Mfg. Co., Chicago 44, Ill.	70903
Birnbach Radio Company, New York 13, N.Y.	71002
Birtcher Corporation, North Los Angeles, Calif.	07387
Bud Radio Inc., Cleveland, Ohio	71218
Bussman Mfg. Co., St. Louis, Mo.	71400

MANUFACTURER'S CODE (Continued)

(Name to Code)

California Resistor Corp., Santa Monica, Calif.	14193
Centralab Civ. Globe Union, Inc., Milwaukee 1, Wis.	71590
Cinch Mfg. Co., Chicago 24, Ill.	71785
Clarostat Mfg. Co., Dover, N.H.	12697
Columbus Electronics, Yonkers, N.Y.	81751
CTS Corporation, Elkhart, Ind.	71450
Cornell-Dubilier Electric Corp., Indianapolis, Ind.	88419
Corning Glass Works, Bradford, Pa.	07115
Dage Electric Co., Inc., Beech Grove, Ind.	95712
Dale Electronics, Inc., Columbus, Nebr.	91637
Daystrom Corp., Newark, N.J.	65092
Dialight Corporation, Brooklyn 37, N.Y.	72619
Drake Mfg. Co., Chicago 22, Ill.	72765
E.F. Johnson Co., Waseca, Minn.	74970
Eldema Corporation, El Monte, Calif.	03797
Electra Mfg. Co., Kansas City, Mo.	19701
Electro Assemblies, Inc., Chicago, Ill.	09250
Electro Motive Mfg. Co., Willimantic, Conn.	72136
Electronic Industries Associates, Washington, D.C.	80131
Erie Resistor Corporation, Erie 6, Pa.	72982
Essex Electronics, Inc., Berkley Heights, N.J.	72259
Fairchild Semiconductor Corp., Mountain View, Calif.	07263
Florida Transformer Co., DeLeon Spring, Fla.	08914
General Electric Co., Owensboro, Ky.	33173
Good All Electric Mfg. Co., Ogallala, Nebr.	84411
Gould-National Batteries, Inc., St. Paul, Minn.	88220
Gremar Mfg. Co., Wakefield, Mass.	91737
Hammarlund Co., Inc., New York 1, N.Y.	80583
Herman H. Smith, Inc., Brooklyn, N.Y.	83330
Heyman Mfg. Co., Kenilworth, N.J.	28520
Hi-Q Division of Aerovox Corp., Myrtly Beach, S.C.	04222
Hugh H. Eby, Inc., Philadelphia, Pa.	72825
Hughes Products Div. Hughes Aircraft Co., Los Angeles, Calif.	73293
Industrial Devices, Inc., Edgewater, N.J.	91802
International Electronics Industries, Inc., Nashville, Tenn.	02567
International Rectifier Corp., El Segundo, Calif.	81483
International Resistance Co., St. Petersburg, Fla.	75042
James Millen Mfg. Co., Inc., Malden, Mass.	76487
Joint Army-Navy Specifications (JAN)	81350
Joint Electronic Tube Council (Jetec), Washington, D.C.	07688
J.W. Millwer Co., Los Angeles, Calif.	76493
Kelvin Electric Co., Van Nuys, Calif.	07088
Kulka Electric Mfg. Co., Inc., Mt. Vernon, N.Y.	75382
Line Electric Company, Newark, N.J.	07065
Littelfuse, Inc., Des Plaines, Ill.	75915
MEC, Inc., Nashville, Tenn.	11903
Merit Coil and Transformer Corporation, Hollywood, Fla.	74042
Military Specifications (MIL)	81349
Military Standards (MS)	96906
Motorola, Inc., Phoenix, Ariz.	94990

MANUFACTURER'S CODE (Continued)

(Name to Code)

Muter Company, Chicago 5, Ill.	42190
North American Electronics, Inc., Lynn, Mass.	06486
Oak Mfg. Co., Chicago 10, Ill.	76854
Ortho Filter Corp., Paterson, N.J.	03045
Peterson Radio Co., Council Bluffs, Iowa	01807
Philco Corp., Lansdale, Pa.	46859
Plastic Capacitors, Inc., Chicago, Ill.	99120
Potter and Brumfield, Inc., Princeton, Ind.	77342
Radio Materials Co., Chicago, Ill.	91418
Radio Receptor Co., Inc., Brooklyn, N.Y.	77638
Raytheon Mfg. Co., Wayland, Mass.	98687
RCA, Somerville, N.J.	02735
RCA Tube Division, Harrison, N.J.	86684
Rotron Mfg. Co., Woodstock, N.Y.	82877
Sloan Co., Burbank, Calif.	08717
Sonotone Corp., Elmsford, N.Y.	55933
Sperry Microwave Electronics Company, Clearwater, Fla.	06424
Sprague Electric Co., North Adams, Mass.	56289
Superior Electric Co., Bristol, Conn.	58474
Switchcraft, Inc., Chicago 22, Ill.	82389
Sylvania Electric Products, Inc., Emporium, Pa.	82219
Synchro Corporation, Hicksville, Ohio	12674
Tepro of Florida, Dunedin, Fla.	15915
Texas Instruments, Inc., Dallas, Texas	01295
Tinnerman Products, Inc., Cleveland, Ohio	78553
Tower Mfg. Co., Providence 3, R.I.	60437
Transformer Technician, Inc., Chicago, Ill.	96253
Triad Transformer Corporation, Venice, Calif.	81095
Tung-Sol Electric, Inc., Newark 4, N.J.	94154
Ultronix, Inc. San Mateo, Calif.	61577
Unimax Switch Div., W.L. Maxon Corp., Wallingford, Conn.	80207
United International Dynamics Corp., Waltham, Mass.	0000A
Veeder-Root, Inc., Hartford, Conn.	79142
Walsco Electronics Corp., Rockford, Ill.	04941
Weinschel Engineering Co., Kensington, Md.	93459
Winchester Electronics, Inc., Norwalk, Conn.	81312
Workman Electronics, Sarasota, Fla.	13664

TABLE OF REPLACEABLE PARTS

Reference Designation	Description	Mft. Code	Sperry Part No.	Quantity per Unit
B1	BATTERY: Nickel-Cadmium, Rechargeable, 24.0 volts nominal	55933	C-02920	1
*C1	CAPACITOR: Fixed, Mica, 500 vdcw, ±1%	88419	A-01220-*	1
*C2	CAPACITOR: Fixed, Mica, 2250 pf, ±1% min., 500 vdcw	88419	A-01220-018	1
C3	CAPACITOR, Variable, 7-144 pf	80583	A-01245-2	1
*C4	CAPACITOR; Fixed, Mica, 500 vdcw, ±1%	88419	A-01220-*	1
C5	CAPACITOR: Fixed, Electrolytic, 60 μf-10 +100%, 6 vdcw	56289	A-01233-101	1
*C6	CAPACITOR: Fixed, Mica, 500 vdcw, ±1%	88419	A-01220-*	1
C7	CAPACITOR: Fixed, Mica, 500 vdcw, ±1%	88419	A-01220-*	1
C8	Unassigned			
C9	Unassigned			
C10	CAPACITOR: Fixed Mylar, 0.33 μf ±20%, 50 vdcw	84411	A-01203-508	2
C11	CAPACITOR: Fixed, Electrolytic, 10 μf, -10 +100%, 25 vdcw	56289	A-01233-301	5
C12	Same as C11			
C13	Same as C10			
C14	CAPACITOR; Fixed, Poly Metal Case, 0.1 ±2%, 50 vdcw	56289	A-01204-505	3
C15	CAPACITOR: Fixed, Electrolytic, 20 μf, -10 +100%	56289	A-01233-302	1
C16	CAPACITOR: Fixed, Mylar, 0.22 μf, ±20%, 50 vdcw	84411	A-01203-507	2
C17	Same as C14			
C18	Same as C11			
C19	Same as C14			
C20	CAPACITOR: Fixed, Electrolytic, 50 μf, -10 +100%, 25 vdcw	56289	A-01233-304	3
C21	Same as C11			
C22	Same as C20			
C23	CAPACITOR; Fixed, Electrolytic, Bi-polar 50 μf, -10 +100%, 25 vdcw	56289	A-01233-306	1
C24	Same as C16			
C25	CAPACITOR: Fixed, 0.47 μf, +80%, -20%, 25 vdcw	56289	A-01214-474	1
C26	CAPACITOR: Fixed, Disk, 0.1 μf, +80%, -20%, 100 vdcw	91418	A-01212-100	1
C27	Unassigned			
C28	CAPACITOR: Fixed, Electrolytic, 50 μf, -10 +100%, 50 vdcw	56289	A-01233-402	1
C29	CAPACITOR: Fixed, Electrolytic, 40 μf, -10 +100%, 50 vdcw	56289	A-01233-404	1
C30	CAPACITOR: Fixed, Disk, 0.01 μf, ±20%		A-01211-010	1
C31	Same as C11			
C32	Same as C20			
CR1	DIODE: Zener Regulator, 1N754	94990	A-01959-3	4

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Sperry Part No.	Quantity per Unit
CR2	Same as CR1			
CR3	DIODE: Ge, 1N100	72982	A-01950-3	5
CR4	Same as CR3			
CR5	Same as CR3			
CR6	Same as CR3			
CR7	Same as CR3			
CR8	DIODE: Si, 1N645	72982	A-01951-1	5
CR9	Not used			
CR10	Same as CR8			
CR11	Same as CR8			
CR12	Same as CR8			
CR13	Same as CR8			
CR14	Same as CR1			
CR15	DIODE: Zener Regulator, 1N941	94990	A-01959-4	1
CR16	Same as CR1			
CR17	Not used			
CR18	DIODE: Si, 1N457	72982	A-01951-2	5
CR19	Same as CR18			
CR20	Same as CR18			
CR21	Same as CR18			
CR22	Same as CR18			
DS1	LAMP: Red, NE-2	03797	A-01853-102	1
J1	CONNECTOR: Female, 6-pin	02660	C-02725-41	1
J2	JACK: Phone, Accepts Two-Conductor plug	82389	A-01731-2	1
J3	CONNECTOR: Power, Male, 3-pin	60437	A-01735-5	1
J4	POST: Binding, Nylon, Red, 6-way	74970	A-01722-2	1
J5	POST; Binding, Nylon, Black, 6-way	74970	A-01722-3	1
J6	CONNECTOR: BNC	95712	724102	1
L1	INDUCTOR: 2.5 Mh, ±5% at 10-kc, 2.35Ω	06424	B-02462-1	3
L2	Same as L1			
L3	Same as L1			
L4	Part of Z1, nor normally separately replaceable			
L5	COIL: Variable, 2-windings, 9-20 μh	06424	C-02488-1	2
L6	Same as L5			
M1	METER: Calibrated, with mirror, 1 ma	65092	A-02511-1	1
Q1	TRANSISTOR: 2N1370	01295	A-01964-5	6
Q2	TRANSISTOR; 2N1304	01295	A-01964-3	4
Q3	TRANSISTOR: 2N383	82219	A-~~91964~~-6	1
Q4	Same as Q2			
Q5	Same as Q1			
Q6	Same as Q2			
Q7	TRANSISTOR	07263	A-02960-1	4
Q8	Same as Q1			
Q9	Same as Q1			
Q10	Same as Q2			
Q11	Same as Q7			
Q12	Same as Q1			
Q13	TRANSISTOR: Power, 2N1183	02735	A-01963-2	1

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Sperry Part No.	Quantity per Unit
Q14	Same as Q1			
Q15	Same as Q7			
Q16	Same as Q7			
R1	Unassigned			
R2	RESISTOR: Wirewound, 0.25w, 200.3 ohm, ±0.1%	61577	A-01134-2	3
R3	Same as R2			
R4	RESISTOR: Wirewound, 0.25w, 256 ohm, ±0.5%	61577	A-01134-3	1
R5	Same as R2			
R6	RESISTOR: Wirewound, 1w, 125 ohm, ±1%	06424	A-1130-15	1
R7	POTENTIOMETER: Wirewound, Dual, Concentric, 2w, 800/10k ohm, ±10%	71450	B-02156-1	2
R8	Same as R7			
R9	RESISTOR: Fixed, Composition, 0.25w, 24 K, ±10%	01121	63284-82	1
R10	RESISTOR; Fixed, Composition, 1 w, 4.7 ohm, ±5%	01121	0525-160	1
R11	RESISTOR: Fixed, Composition, 0.25w, 22 ohm, ±10%	01121	A-01105-220	1
R12	RESISTOR: Fixed, Composition, 0.25w, 68 ohm, ±10%	01121	A-01105-680	2
R13	RESISTOR: Fixed, Composition, 0.25w, 220 ohm, ±10%	01121	A-01105-221	1
R14	RESISTOR: Fixed, Composition, 0.25w, 120 ohm, ±10%	01121	A-01105-121	1
R15	RESISTOR: Fixed, Composition, 0.25w, 470 ohm, ±10%	01121	A-01105-471	1
R16	RESISTOR: Fixed, Composition, 0.25w, 2700 ohm, ±10%	01121	A-01105-272	1
R17	RESISTOR: Fixed, Composition, 0.25w, 20k, ±10%	01121	632284-80	1
R18	RESISTOR: Fixed, Composition, 0.25w, 8200 ohm, ±10%	01121	A-01105-822	1
R19	RESISTOR: Fixed, Composition, 0.5w, 1500 ohm, ±5%	01121	0524-53	1
R20	RESISTOR; Deposited Carbon, 0.5w, 1200 ohm, ±0.5%	75042	A-01118-802	1
R21	RESISTOR: Deposited Carbon, 0.5w, 2133 ohm, ±0.5%	75042	A-01118-803	1
R22	RESISTOR: Deposited Carbon, 0.5w, 3795 ohm, ±0.5%	75042	A-01118-804	1
R23	RESISTOR: Deposited Carbon, 0.5w, 6749 ohm, ±0.5%	75042	A-01118-805	1
R24	RESISTOR: Deposited Carbon, 0.5w, 12k ohm, ±0.5%	75042	A-01118-806	1
R25	RESISTOR: Deposited Carbon, 0.5w, 21.33k ohm, ±0.5%	75042	A-01118-807	1
R26	RESISTOR: Deposited Carbon, 0.5w, 37.95k ohm, ±0.5%	75042	A-01118-808	1

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Sperry Part No.	Quantity per Unit
R27	Unassigned			
R28	Unassigned			
R29	Unassigned			
R30	RESISTOR: Deposited Carbon, 0.5w, 3000 ohm, ±1%	91637	A-01120-302	2
R31	Same as R30			
R32	RESISTOR: Fixed, Composition, 0.5w, 3300 ohm, ±5%	81349	0524-61	10
R33	RESISTOR: Fixed, Composition, 0.5w, 470 ohm, ±5%	81349	0524-41	1
R34	RESISTOR: Fixed, Composition, 0.5w, 200 ohm, ±5%	81349	0524-32	1
R35	RESISTOR: Fixed, Composition, 0.5w, 0.1 meg, ±5%	01121	0524-97	1
R36	Unassigned			
R37	Unassigned			
R38	Unassigned			
R39	Unassigned			
R40	Same as R12			
R41	RESISTOR: Fixed, Composition, 0.5w, 5600 ohm, ±5%	81349	0524-67	1
R42	Unassigned			
R43	RESISTOR: Fixed, Composition, 0.5w, 2700 ohm, ±5%	81349	0524-59	1
R44	Same as R32			
R45	RESISTOR: Fixed, Composition, 0.5w, 1800 ohm, ±5%	81349	0524-55	2
R46	RESISTOR; Fixed, Composition, 0.5w, 7500 ohm, ±5%	81349	0524-70	1
R47	RESISTOR: Fixed, Composition, 0.5w, 15k ohm, ±5%	81349	0524-77	3
R48	Same as R32			
R49	Same as R32			
R50	RESISTOR: Fixed, Composition, 0.5w, 220 ohm, ±5%	81349	0524-33	2
R51	Same as R32			
R52	Unassigned			
R53	Unassigned			
R54	Unassigned			
R55	RESISTOR: Fixed, Composition, 0.5w, 150 ohm, ±5%	81349	0524-29	1
R56	RESISTOR: Fixed, Composition, 0.5w, 18k ohm, ±5%	81349	0524-79	1
R57	Same as R50			
R58	RESISTOR: Fixed, Composition, 0.5w, 10 ohm, ±5%	81349	0524-1	1
R59	RESISTOR: Fixed, Composition, 0.5w, 1000 ohm, ±5%	81349	0524-49	5

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Sperry Part No.	Quantity per Unit
R60	Same as R59			
R61	Same as R59			
R62	Same as R59			
R63	Same as R32			
R64	Same as R47			
R65	Same as R47			
R66	RESISTOR:, Fixed, Composition, 0.5w, 10k ohm, ±5%	81349	0524-73	2
R67	Same as R32			
R68	RESISTOR: Fixed, Composition, 0.5w 1200 ohm, ±5%	81349	0524-51	1
R69	Same as R59			
R70	RESISTOR: Fixed, Composition, 0.5w, 100k ohm, ±5%	81349	0524-97	1
R71	Same as R32			
R72	RESISTOR: Fixed, Composition, 1w, 390 ohm, ±5%	81349	0525-39	1
R73	RESISTOR: Fixed, Composition, 0.5w, 22 ohm, ±5%	81349	0524-9	1
R74	RESISTOR: Fixed, Composition, 1w, 1200 ohm, ±5%	81349	0525-51	1
R75	RESISTOR: Fixed, Composition, 0.5w, 270 ohm, ±5%	81349	0524-35	1
R76	RESISTOR: Fixed, Composition, 0.5w, 4700 ohm, ±5%	81349	0524-65	1
R77	Same as R32			
R78	Part of Z1			
R79	Same as R66			
R80	Same as R32			
R81	Same as R45			
R82	RESISTOR: Fixed, Film, 0.5w, 10k ohm, ±5%	07115	A-01103-103	1
R83	POTENTIOMETER: Composition, 3300 ohm, ±10%	71450	B-02158-332	1
R84	RESISTOR: Fixed, Film, 0.5w, 4700 ohm,±5%	07115	A-01103-472	1
R85	Unassigned			
R86	Unassigned			
R87	Unassigned			
R88	Unassigned			
R89	Unassigned			
R90	RESISTOR: Deposited Carbon, 0.5w, 91.08k ohm, ±0.5%	75042	A-01118-809	1
R91	RESISTOR: Deposited Carbon, 0.5w, 38.05k ohm, ±0.5%	75042	A-01118-810	1
R92	RESISTOR: Deposited Carbon, 0.5w, 43.40k ohm, ±0.5%	75042	A-01118-811	1
R93	RESISTOR: Deposited Carbon, 0.5w, 50.69k ohm, ±0.5%	75042	A-01118-812	1

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Sperry Part No.	Quantity per Unit
R94	RESISTOR: Deposited Carbon, 0.5w, 59.01k ohm, ±0.5%	75042	A-01118-813	1
R95	RESISTOR: Deposited Carbon, 0.5w, 71.70k ohm, ±0.5%	75042	A-01118-814	1
R96	RESISTOR: Deposited Carbon, 0.5w, 413.8k ohm, ±0.5%	75024	A-01118-815	1
R97	RESISTOR: Deposited Carbon, 0.5w, 181.8k ohm, ±0.5%	75024	A-01118-816	1
R98	RESISTOR: Deposited Carbon, 0.5w 116.0k ohm, ±0.5%	75042	A-01118-817	1
R99	RESISTOR: Deposited Carbon, 0.5w, 80.84k ohm, ±0.5%	75042	A-01118-818	1
R100	RESISTOR: Deposited Carbon, 0.5w, 63.14k ohm, ±0.5%	75042	A-01118-819	1
R101	RESISTOR: Deposited Metal Film, 0.5w, 2370 ohm, ±1%	75042	A-01104-337	1
R102	RESISTOR: Deposited Metal Film, 0.5w, 787 ohm, ±1%	75042	A-01104-287	1
R103	RESISTOR: Deposited Metal Film, 0.5w, 392 ohm, ±1%	75042	A-01104-258	1
R104	RESISTOR: Deposited Metal Film, 0.5w, 1180 ohm, ±1%	75042	A-01104-308	1
R105	RESISTOR: Deposited Carbon, 0.5w, 4121 ohm, ±1%	75042	A-01115-360	1
R106	RESISTOR: Deposited Carbon, 0.5w, 1370 ohm, ±1%	75042	A-01115-314	1
R107	RESISTOR: Deposited Carbon, 0.5w, 825 ohm, ±1%	75042	A-01115-289	1
R108	RESISTOR: Deposited Carbon, 0.5w, 1650 ohm, ±1%	75042	A-01115-322	1
R109	RESISTOR: Deposited Carbon, 0.5w, 348 ohm, ±0.5%	75042	A-01118-253	1
R110	RESISTOR: Fixed Film, 0.5w, 51k ohm, ±5%	07115	A-01103-513	1
S1	SWITCH: Slide, 4PDT	06424	A-01659-842	1
S2	SWITCH: Rotary, RANGE	76854	B-02675-1	1
S3	SWITCH: Rotary, POWER	76854	B-02676-3	1
S4	SWITCH: Slide, DPDT	06424	A-01659-722	1
S5	SWITCH: Rotary	76854	A-02680-1	1
T1	TRANSFORMER: Audio	06424	A-02419	2
T2	Same as T1			
T3	TRANSFORMER, Audio	06424	A-02420	2
T4	Same as T3			
T5	TRANSFORMER, Power	06424	A-02421	1
Z1	CHOKE, Includes L4, R78, 68Ω/0.1 ma	06424	A-02478-2	1
	KNOB: Zero Adjustment	06424	D-30040-1	1
	KNOB: Mode Selection and RANGE Switches	06424	D-30040-2	2
	KNOB: Zero Adjustment	06424	D-30040-16	1

TABLE OF REPLACEABLE PARTS (Continued)

Reference Designation	Description	Mfr. Code	Sperry Part No.	Quantity per Unit
C201	CAPACITOR: Fixed, Electrolytic, 10 μf, +100%, −10%, 100 vdcw	56289	A-01233-602	1
C202	CAPACITOR: Fixed, Electrolytic, 10 μf, +100%, −10%, 50 vdcw	56289	A-01233-401	1
C203	CAPACITOR: Fixed, Electrolytic, 10 μf, +100%, −10%, 150 vdcw	56289	A-01233-702	1
C204	CAPACITOR: Fixed, Electrolytic, 5 μf, +100%, −10%, 150 vdcw	56289	A-01233-701	1
C205	CAPACITOR: Disk, 0.1 μf, +80%, −20%, 100 vdcw → CAPACITOR: FIXED TUBULAR CERAMIC 400 vdcw	91418	A-01212-100	1
[illegible]	[illegible]	00656	A-01205-226	1
CR201	DIODE: Silicon, 1N645	01295	A-01951-1	3
CR202	Same as CR201			
CR203	Same as CR201			
CR204	DIODE: Zener Regulator, 1N1371	94990	A-01959-8	1
Q201	TRANSISTOR: 2N1370	46859	A-01964-5	2
Q202	Same as Q201			
Q203	TRANSISTOR: NPN High Voltage	73445	A-02961	1
R201	RESISTOR: Fixed, Composition, 0.5w, ~~5600~~ 1200 ohm, ±5%	01121	~~0524-67~~ 0524-37	2
R202	Same as R201			
R203	RESISTOR: Fixed, Composition, 0.5w 47k ohm, ±5%	01121	0524-89	1
R204	RESISTOR: Deposited Metal Film, 0.5w, 16.5k ohm, ±1%	75042	A-01104-422	1
R205	RESISTOR: Fixed, Composition, 0.5w, 470 ohm, ±5%	01121	0524-41	2
R206	RESISTOR: Fixed, Composition, 0.5w, 4700 ohm, ±5%	01121	0524-65	1
R207	RESISTOR: Fixed, Composition, 0.5w, 15k ohm, ±5%	01121	0524-77	1
R208	RESISTOR: Variable, Composition, 1000 ohm, with switch S201	71450	A-02161-1	1
R209	RESISTOR: Deposited Metal Film, 0.5w, 499 ohm, ±1%	75042	A-01104-268	1
R210	Same as R205			
R211	RESISTOR: Fixed, Composition, 0.5w, 2700 ohm, ±5%	01121	0524-59	1
S201	Part of R208			

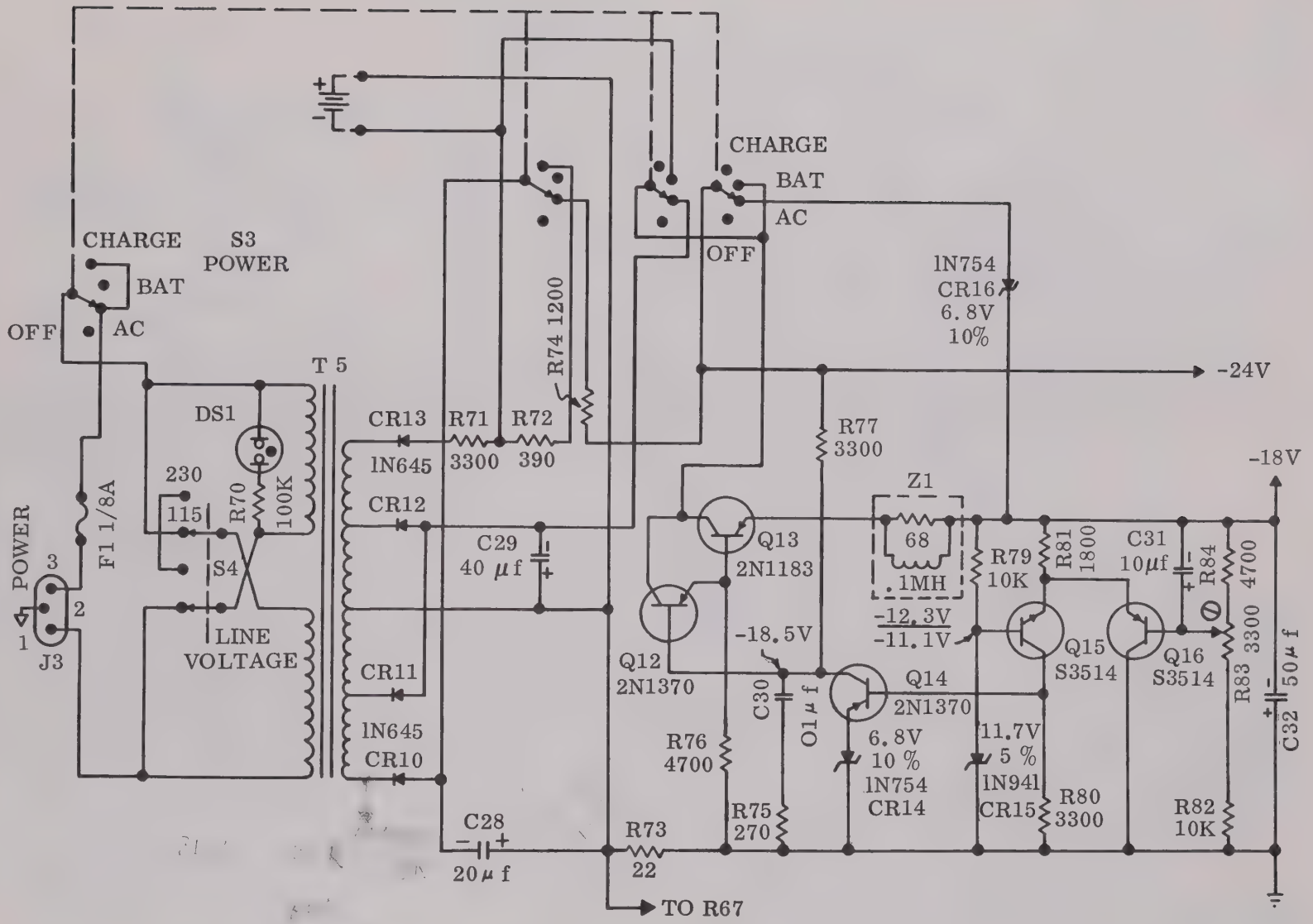


Figure 26. Power Supply, Schematic Diagram

POWER SUPPLY 66A2

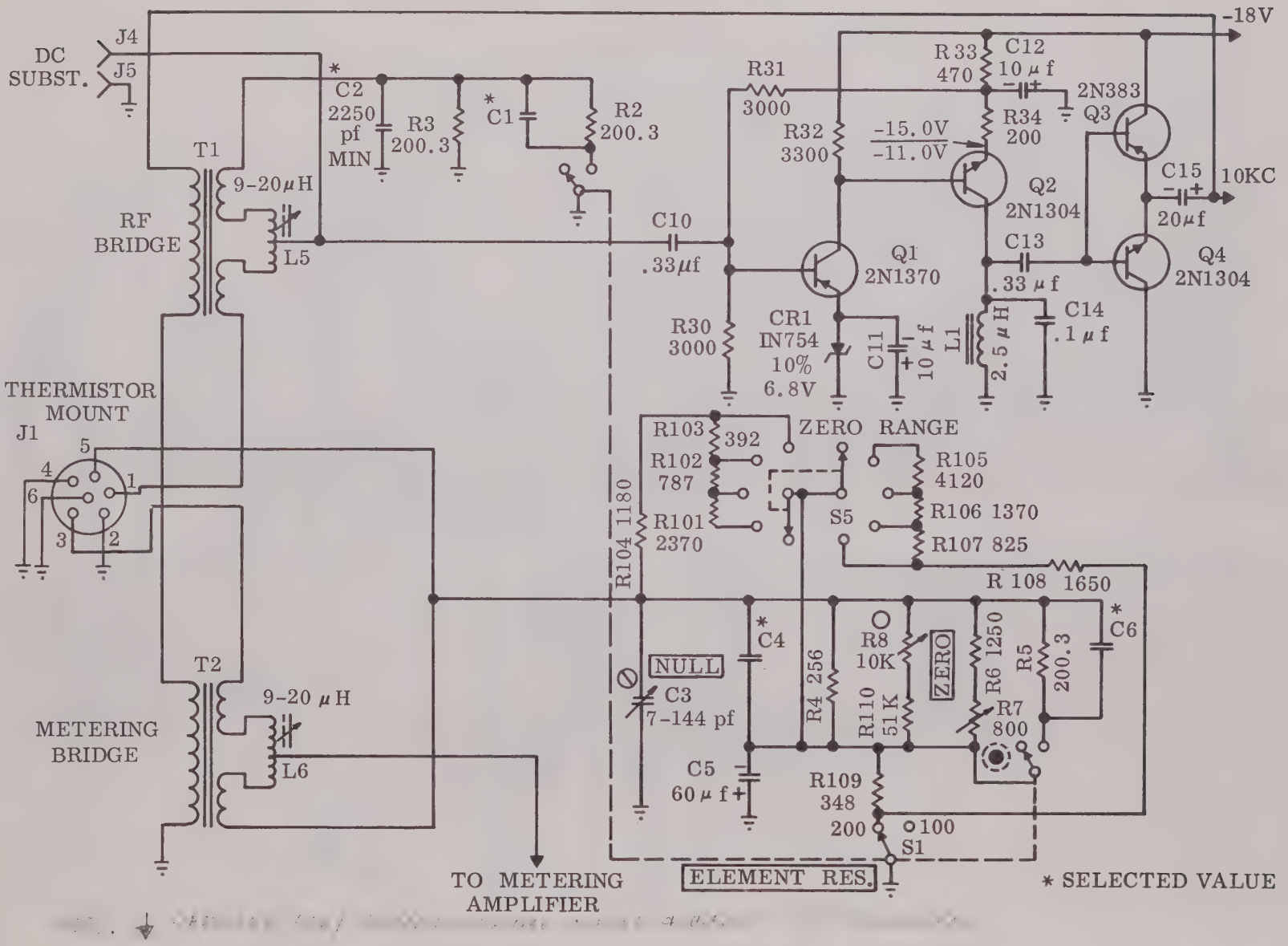


Figure 27. Bridge Oscillator, Schematic Diagram

BRIDGE OSCILLATOR 66A2

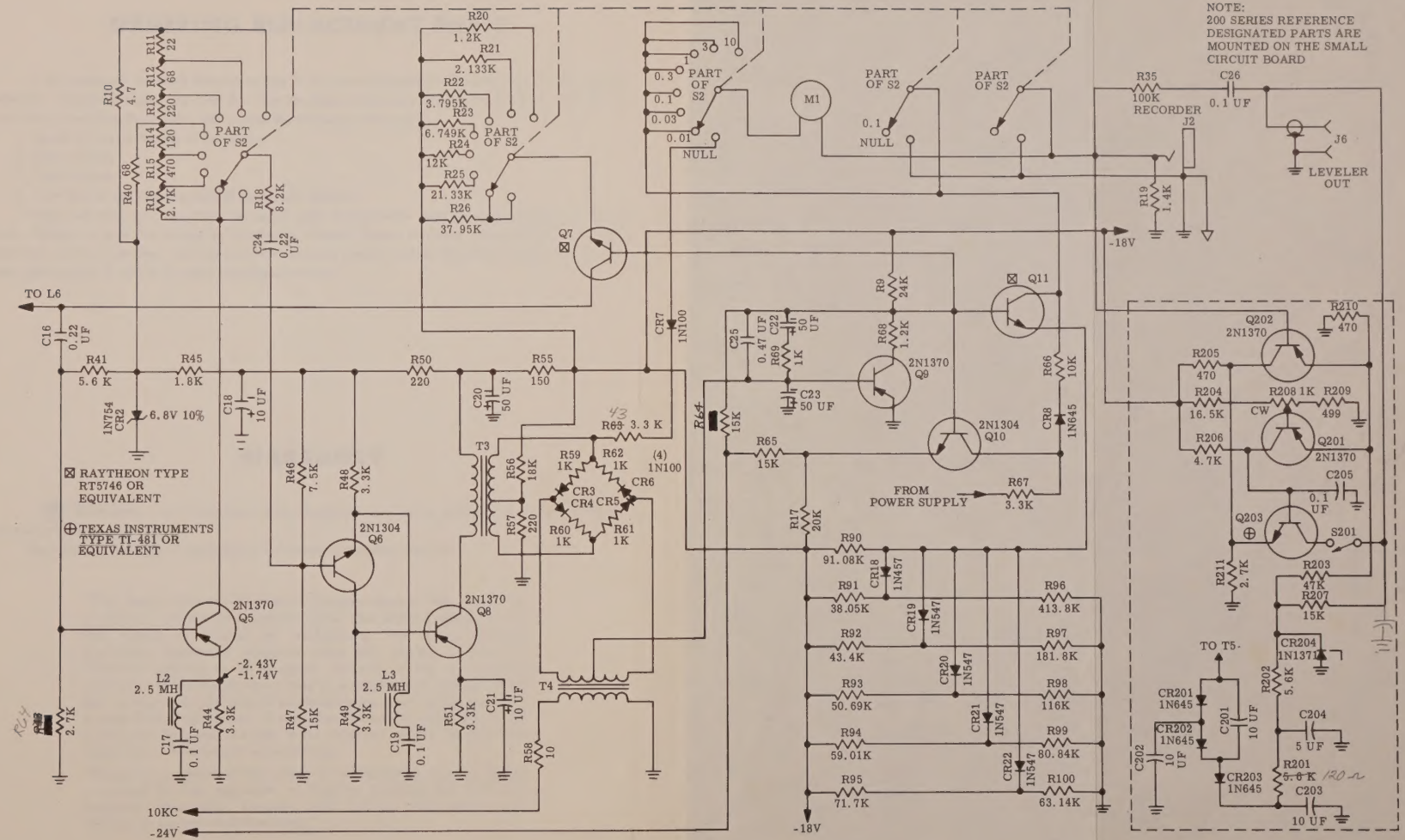


Figure 28. Metering Amplifier, Schematic Diagram

ORDERING REPLACEMENT PARTS

If the equipment becomes inoperative and it has been definitely determined that a component is defective, replacement parts are available from the Sperry Microwave Electronics Company. Address all inquiries to the Sales Department, and include the following information:

1. Model and Serial Number of Equipment
2. Date of Order
3. Order Number
4. Part Number and Nomenclature of Component Desired

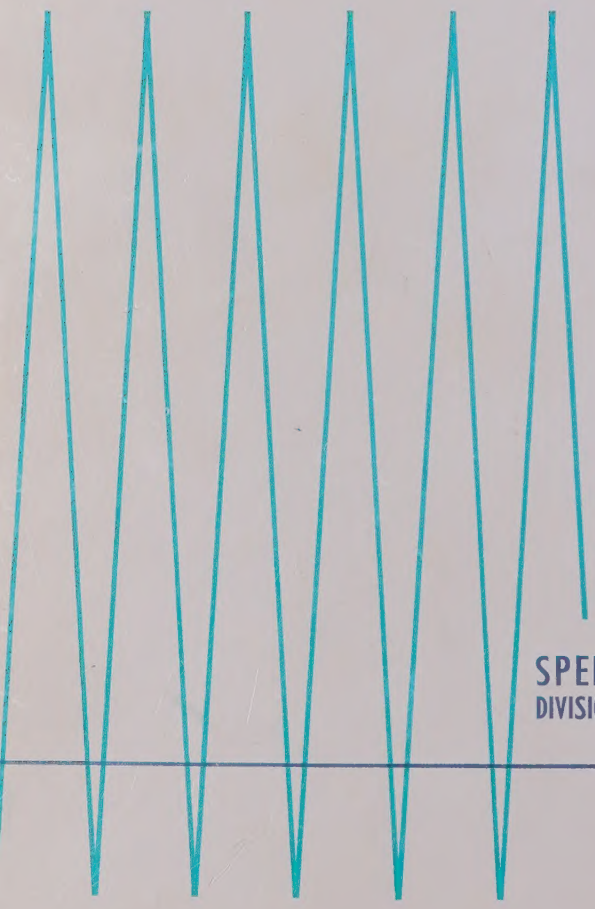
Before returning any equipment for repair, prior arrangements must be made through one of the Sales Offices or with the factory at Clearwater, Florida. Repair facilities are maintained at several locations, and this procedure will assure shipment to the proper location and proper routing of the equipment after receipt to assure the most expeditious service.

WARRANTY

SPERRY *Microline*® is a registered Sperry trademark applied to quality products of the Sperry Microwave Electronics Company.

The following Warranty is applicable to all standard Microline products:

> "The Sperry Microwave Electronics Company warrants that, at the time of delivery, all Microline products (other than electron tubes) are free from defects in material and workmanship. The Sperry Microwave Electronics Company's obligation under this warranty, however, is limited to repairing or, at its option, replacing, at any of its service stations or at its factory, any article or part (other than electron tubes) that is returned by the original purchaser to any such service station or to such factory within one (1) year after the date on which the original article was delivered, and that in the judgement of this Company after inspection, is defective or nonconforming.
>
> "Except for a warranty of title, there are no warranties, express, implied or implied by law applicable to Microline products; and the Sperry Microwave Electronics Company shall have no other obligation or liability, on account of such articles."



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